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FRIDAY, MARCH 24, 1899.

CONTENTS:

The Early Tertiary Volcanoes of the Absaroka Range: ARNOLD HAGUE..... 425

The Physiological Basis of Mental Life: PROFESSOR HUGO MÜNSTERBERG..... 442

Sophus Lie: PROFESSOR GEORGE BRUCE HALSTED 447

Scientific Books:—
Newbigin on Color in Nature: PROFESSOR T. D. A. COCKERELL. *Weir on the Dawn of Reason:* DR. EDWARD THORNDIKE..... 448

Scientific Journals and Articles:..... 450

Societies and Academies:—
The Annual Meeting of the New York Academy of Sciences: PROFESSOR RICHARD E. DODGE. *The Philosophical Society of Washington:* E. D. PRESTON. *The Geological Society of Washington:* DR. WM. F. MORSELL..... 452

Discussion and Correspondence:—
On the Making of Solutions: PROFESSOR M. A. WILLCOX. *The Origin of Nightmare:* G. V. D..... 455

Astronomical Notes:—
A New Satellite of Saturn: PROFESSOR E. C. PICKERING..... 456

Notes on Physics:—
The Nernst Lamp; Pyroelectricity and Piëzoelectricity; The Rotary Converter; The Telescope-Mirror-Scale Method: W. S. F..... 456

Notes on Inorganic Chemistry: J. L. H..... 457

Current Notes on Meteorology:—
The Theory of Cyclones and Anticyclones; Carbonic Acid in Death Gulch: R. DEC. WARD... 458

Zoological Notes:—
Neomylodon Listai: F. A. L..... 459

Scientific Notes and News..... 460

University and Educational News..... 464

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*THE EARLY TERTIARY VOLCANOES OF THE ABSAROKA RANGE.**

IT is, I suppose, accepted by many geologists that volcanic energy has played an important part not only in bringing about the present configuration of the Rocky Mountains, but in building up the entire northern Cordillera, stretching from the Front Range, along Colorado, Wyoming and Montana, westward to the Pacific Ocean. Over this wide area the volcanic phenomena of Tertiary time present a varied and complex mode of occurrence, offering from different points of view many problems of geological interest. These problems have been vigorously attacked both in the field and in the laboratory, and something has been accomplished tending toward their final elucidation. The literature upon the subject is already voluminous, being scattered widely through the publications of official reports, both State and National, and in the proceedings of scientific societies. While I desire to call your attention to some of these features, I do not propose to summarize the work that has already been done in this direction in a manner which is perhaps usual on occasions like the present. Neither do I wish to review the field from my own standpoint, possibly because, although much has been accomplished, such a vast amount of work remains to be done that the broad

*Address of the President before the Geological Society of Washington, February, 1899.

field seems even yet scarcely explored. I prefer, therefore, to place before you some results of personal observation in a region in which I have worked for several years and in which I have become deeply interested.

The Absaroka Range lies along the east side of the Yellowstone Park. Several of its higher peaks and its long western spurs, sloping gradually toward the Park, lie within the national reservation. During several successive summers, while engaged in geological observations in the Park, I found it necessary to penetrate beyond its boundaries into the higher encircling mountains. My first excursion into the Absarokas was undertaken in the summer of 1885, and thereafter for several years I made long and protracted journeys into this rugged and at that time almost unknown region, studying its geology, and returning each year more and more profoundly impressed by its many marvels. In the year 1893, and again in 1897, the greater part of the summer was occupied in exploration of the wild recesses of the Absarokas.

The range, which lies wholly in the State of Wyoming, stretches from the Beartooth and Snowy ranges, on the north, southward to the Owl Mountains. In width it is less sharply defined, certain outlying plateau-like areas, such as Mirror and Two-Ocean plateaus, being separated from the main body by deep valleys. Geographically they may be considered as distinct physical features. Geologically, from their mode of occurrence and the nature of the rocks, they are intimately associated with the central mass, and for the purposes of this address they may be considered as forming a part of the Absaroka Range. As thus defined, the range measures 80 miles in length by 50 miles in width, covering an area of nearly 4,000 square miles.

From one end to the other the Absarokas present a high, imposing plateau, with elevations ranging from 10,000 to over 12,000 feet above sea level. This entire mass is made up almost exclusively of Tertiary igneous rocks. Near the northern flanks Archean schists and gneisses crop out from beneath the overlying rocks. Resting upon the Archean, upturned Paleozoic limestones and sandstones having a considerable thickness come to the surface, and along the eastern borders of the range, exposed by erosion in the broader valleys, occur Cretaceous rocks. With these exceptions, the range consists of a vast accumulation of agglomerates, tuffs, lava flows and intrusive masses.

Degradation of the mass has taken place on a grand scale. Vast quantities of volcanic ejectamenta have been removed from the summit, but no reliable data exist by which the amount can be estimated even approximately. All the higher portions have been sculptured by glacial ice. Enormous amphitheatres have been carved out of the loose agglomerates, and peaks, pinnacles, and relics of great tablelands testify in some measure to the forces of erosion. The plateau is scored by a complete network of deep valleys and gorges, which dissect it in every direction and lay bare the structure of the vast volcanic pile.

Nowhere in the northern Rocky Mountains do I know grander and more rugged scenery than can be found in the Absarokas. But few natural passes lead across the mountainous tract, and these are high and difficult to scale. For years the range stood as an impassable barrier to the earlier explorers in their attempts to reach the sources of the Yellowstone from the east; and even to-day the region is seldom penetrated to its inmost recesses except by those engaged in scientific exploration of the country, by the prospector in search of precious metals, or by a few adventurous sportsmen in pursuit of the big game of the Rockies. Much of this region is covered by a dense growth of

coniferous forest, and the greater part of the forests lying east of the Yellowstone Park belong to the Yellowstone timber reserve, the first of the forest reservations set aside by proclamation of the President under the Act of Congress approved March 1, 1891.

Rightly to understand the true position of this volcanic area it is necessary to review briefly the geological history of the surrounding region before the piling-up of the eruptive material. The Absarokas are hemmed in, both to the north and to the south, by high ranges with approximately east and west trends. On the north are the Beartooth Mountains, presenting a broad elevated Archean mass culminating in some of the highest peaks to be found in Montana; while to the south are the Owl Mountains, consisting of an Archean nucleus capped and for the most part concealed by an arch of Paleozoic beds highly inclined along the outer edges. Between these two ranges lies a depressed basin, and resting unconformably upon the Archean are sediments of great thickness, derived in large part from the earlier continental areas.

These sediments, slowly deposited throughout a long period, represent nearly all the great divisions of Paleozoic and Mesozoic time. Beginning with the Cambrian, in their order of sequence, come the Silurian, Devonian, Trias, Jura and all the epochs of the Cretaceous recognized in Wyoming and Montana including the Dakota, Colorado, Montana and the Laramie standstone at the top, with its frequent fluctuations of sea level, foreshadowing changes in the development of the pre-existing continental area.

With the close of the Laramie sandstone the long-continued deposition of Mesozoic and Paleozoic sediments finally came to an end. In this region unconformity of sediments by deposition has not as yet been recognized, and in this sense alone they may be said to be conformable from Middle Cambrian time to the summit of the Laramie. Stupendous orogenic movements took place, and the surrounding country became one of mountain building on a grand scale, accompanied by plication, folding and faulting. The evidence all points in one direction—that this uplifting was contemporaneous in all the ranges of the northern Rocky Mountains. For this reason, and owing to its great geological significance, being one of the most important in Rocky Mountain geological history, the uplifting has been designated as the post-Laramie movement.

Along the west side of the Absarokas, and lying within the Yellowstone Park, extend north and south ridges of faulted and crumbled strata consisting mainly of highly inclined Cretaceous sandstone, the Laramie, nearly 10,000 feet above present sea level. From this ridge region eastward for fifty miles stretches this broad volcanic mass, finally dying out upon the plain over which the earliest lavas spread, resting on horizontal sandstones at an elevation of about 6,000 feet above sea level. After a very considerable erosion of the uplifted Mesozoic continental land area began the earliest of these volcanic eruptions, which later displayed such marvelous energy over this entire region of country, and which were closely related to the post-Laramie movement. This eruptive material, forcing its way upward, followed lines of least resistance along or near planes of faulting, or wherever the strain had been greatest upon the weakened strata.

The Absaroka Range was formed by the piling-up of successive accumulations of volcanic ejectamenta, with occasional interbedded flows of lava, burying everything beneath them to a depth of several thousand feet. Volcanic breccias, agglomerates and extrusive lavas, or those that have been poured out and cooled near the surface, constitute the bulk of the mountains.

These breccias and lavas were ejected from numerous fissures, vents and centers of explosive energy. Infinite detail as regards mineral composition and texture, and great complexity in mode of occurrence, may be observed. Viewed in a broad way and reduced to its simplest terms, the Absaroka Range consists of an uplifted volcanic region, presenting from one end to the other great uniformity, and even simplicity, in its main geological features. It is essentially a dissected plateau, deeply trenched by incisive gorges, offering exposures varying from 2,000 to 5,000 feet of nearly horizontal or only slightly inclined lavas. To this there are, of course, some exceptions, as is natural in any volcanic region. Notwithstanding the varied and complex manifestations of the eruptive breccias from many sources of outflow, this entire body of extrusive material has been divided broadly into six epochs, based upon their relative age and general sequence of lavas. They represent, in the geological history of the mountains, as many distinct phases of volcanic eruption. Beginning with the earliest in the order of eruption, they have been designated as follows: early acid breccia, early basic breccia, early basalt sheets, late acid breccia, late basic breccia, late basalt sheets.

Briefly stated, the interpretation of this history, as I understand it, is somewhat as follows:

So far as is known, the oldest volcanic rocks recognized in the Absarokas consist of a series of eruptives made up almost entirely of fragmental material, usually light in color, varying from grayish white to purple. In mineral composition they range from hornblende-andesite to hornblende-mica-andesite. Some of the siliceous varieties have developed phenocrysts of quartz in sufficient amount to be classed as dacites. These breccias appear to have been thrown out with violent explosive action from numerous centers, but from none of them was any large amount of material piled up; at least if it was thrown out it was subsequently worn down by atmospheric agencies. In no instance do they attain great elevation, the exposures being due to extensive erosion and deep trenching of narrow canyons. They are known only in the northern end of the range, and there in limited area, being buried beneath vast accumulations of still later material. These centers appear to be independent of later eruptions.

Overlying these acid breccias is a vast amount of volcanic ejectamenta, with here and there interbedded basaltic flows, the entire body having accumulated in many places to a height of several thousand feet. They occur far more widely distributed over the mountains than any other group of breccias, stretching both in its length and breadth from one end of the range to the other. They constitute nearly all the northern portion of the Absarokas, as well as the northeast corner of the Park. Unlike the early acid breccia, they are usually dark colored, owing to the amount of ferro-magnesian minerals present. The material consists largely of hornblende-pyroxene-andesite, proxene-andesite and basalt. Constant modifications and transitions occur, but over the entire area the prevailing rock is pyroxene-andesite, passing into slightly less basic rocks carrying hornblende on the one hand and into basaltic forms on the other. By far the greatest portion of this eruptive material is formed of coarse agglomerates, sombre in color, held together by varying amounts of cementing ash and silts of similar composition. The prevailing colors are black and brownish gray, while the finer silts and mud flows free from large bowlders are light brown, in strong contrast to the mass of the breccia.

It is difficult to describe in few words such volumes of volcanic material scattered

over broad fields and thrown out under varying conditions. Frequently these basic breccias present a rough and ropy surface, like ordinrry scoria irregularly heaped together, but the bulk of it indicates indistinct bedding. A tumultuous heaping-up of agglomerate by explosive action characterizes this breccia, which not infrequently carries andesitic and basaltic bowlders measuring 5 and 6 feet in length and often double that size. In one or two localities huge bowlders of crystalline gneisses and schists are also embedded in the lavas.

Scattered over the area occur the thin interbedded flows, apparently poured forth from numerous fissures and vents. These flows increased in frequency and thickness until finally massive outflows of basalt covered a considerable portion of the earlier series of breccias. Over how large a field they at one time may have extended cannot now be told, erosion having certainly removed them from large tracts, but they may never have been spread over extensive regions. It is somewhat curious that this continuous broad field of basalt has a northwest-and-southeast trend and stretches obliquely across the summit of the range from Mirror Plateau to Needle Mountain, whereas the body of the breccia in general has a north-and-south trend. The basalts lie upon the uneven surfaces of the breccia and occur piled up in a succession of flows, which in places near their sources have attained an aggregate thickness of 1,500 feet, although over large areas they measure about 1,000 feet, thinning out to a few hundred, while in certain places they appear to be wanting. Individual sheets range in thickness from 5 to 50 feet without showing any material change in the physical characters of successive flows. The greatest accumulation of flows appears to be along the trend of the basaltic body, thinning out both to the northeast and to the southwest, indicating that the eruptions had followed a fissure or system of fissures. Of course, this can be said only in a general way, as basaltic outflows may occur anywhere along the range. As regards mineral composition, they are usually fine grained, with but few well-developed megascopic constituents, mainly augite, olivine and plagioclase. In chemical composition they show within restricted limits considerable variation, with accompanying changes in mineral development, analyses determining a large amount of the alkalies and a correspondingly low percentage of silica. Numbers of these flows have built up, from vents, rounded bosses of basaltic rocks characterized by a development of orthoclase, in several instances associated with leucite. They are the extrusive equivalents of intrusive rocks, designated as absarokites in distinction from normal basalts. Reference will be made to them later, in speaking of certain intrusive masses. So far as our present knowledge goes, they belong chiefly to this period of eruptions. Many of these individual sheets stretch out for long distances, but others show great lack of continuity, thinning and thickening in different directions and often overlapping one another, indicating numerous sources of eruption and varying force and duration of flows.

In their topograpic configuration the basalts stand out in marked contrast to the loosely compacted breccias, owing to great uniformity of flows and to differences in weathering. To these basalts the name early basalt sheets has been given, and they are here treated as a geological unit, since they mark a distinct period in the history of volcanic eruption. It is quite possible, and even probable, that they covered this entire region and were subsequently removed by erosion, but of this there is no direct evidence. If they did, the country must at one time have presented a gloomy, sombre field of basalt, poured forth in a molten condition after a long period of fragmental

eruptions. How long the basalt period lasted cannot now be told. In determining the sequence of lavas these early basalt fields play an important part, as they overlie the early series of acid and basic breccias and underlie a somewhat similar series of eruptive material designated late acid breccia and late basic breccia and flows.

Following the basalts come the late acid breccias. They occur less widely distributed than the early acid breccias, and for the most part lie within the Yellowstone Park. Unlike the earlier breccias, they are less deeply buried beneath later eruptive material, but are piled up in successive layers one upon another, forming the summits of several prominent peaks and broad, plateau-like ridges. Over considerable areas they lie spread out in thin sheets over the basalt flows. Their centers of eruption occupy a restricted area and seem to be in every way quite independent of the earlier breccias and basalts. In mineral composition they closely resemble the early acid breccias, consisting of hornblende-andesite and hornblende-mica-andesite, in places mingled with a good deal of pyroxene-andesite, both augite and hypersthene being recognized, sometimes one and sometimes the other predominating. Much of the brecciated material is similar in mineral composition to the Ishawooa intrusive bodies, which will be discussed later. Nearly all of this material is fragmental, and the greater part of it is made up of coarse and fine tuffs. Frequently the contact between the light-colored acid breccia and the still later basic breccia is sharply drawn, the latter filling up depressions and levelling the accidented surfaces of the former, which occur at varying altitudes. In most instances the line of demarcation is not so sharply drawn, and not infrequently there is a mingling of material, as if there had been a pouring-out of the later rock before the complete cessation and closing-up of the more acid centers of eruption. Occasionally these light-colored rocks, from what appear to be local centers, lie directly upon basic breccia made up of basaltic bowlders and cementing tuffs of the earlier series, without the intervening basalts. Overlying these acid breccias there poured forth from numerous vents a second great volume of basic rocks and agglomerates, 2,000 to 3,000 feet in thickness, bearing a close resemblance to the earlier basic rocks. They are found over the southern portion of the Absarokas, usually resting upon the basalts, the late acid breccias being, as before mentioned, restricted to a limited region of country. Indeed, the second series of breccias forms the top of nearly all the high plateaus and the summits of the more prominent points. Cross-sections exposed in deep canyons reveal grand escarpments of both breccias, with intervening monotonous sheets of basalts. Viewed in a broad way, these two series of breccias are singularly alike, and apparently the conditions governing their eruptions were much the same. If we are to draw any distinctions, it may be said that the early breccias are apt to be scoraceous and slaggy and more chaotic in their tumultuous accumulation. The later breccia is more regular and distinctly bedded, and is almost wholly made up of both coarse and fine fragmental material, carrying large bowlders that could not have been thrown a great distance from the discharging vents. Bowlders weighing a ton or more are by no means uncommon. In general, it may be said of these later breccias that the coarsest material lies near the present crest of the range, and is seen to grow finer and more uniform, with distinct bedding, as one travels either east or west. To this rule, however, there are marked exceptions.

Following the late basic breccia, basalt tables are found here and there capping the

crest of the main ridge along the southern portion of the range. Probably they are all remnants of one continuous flow. They are best observed when seen eastward from Mountain Basin, when they present a castellated appearance, capping the coarser and lighter-colored rocks. In general habit they resemble the earlier basalt sheets, and, except for their position, have little to distinguish them from other similar flows. The part they play in the present configuration of the plateau is insignificant. The interest lies in the fact that these basalts complete a second cycle of eruption, which built up the Absarokas by the accumulation of successive flows of extrusive lavas, and that with them, so far as we have any positive record, the last phase of a long-continued series of eruptions came to a close.

That the piling-up of this eruptive material lasted through a long period of time is clearly established. In the first place, the early acid breccias show evidences of considerable denudation before the pouring-out of later lavas which now occupy the eroded areas. Not infrequently depressions may be seen filled with water-laid silts and fine gravels, which were afterwards covered by fresh outflows of breccia. Similar water-laid deposits may be observed in all the breccias, but they especially characterize the early basic series along the east side of the range, where the former existence of large lakes and ponds is manifest, with sediments of volcanic material over 200 feet in thickness deposited in comparatively quiet waters. In certain localities the basalts appear to be the result of fitful discharge and slow building-up from numerous vents. The thinning and thickening of beds in various directions, the overlapping of thin beds from different centers, and the frequently chilled surfaces of vesicular basalt, all point to a slow accumulation of the ejected lava. Occasionally in basaltic cliffs between lava sheets may be seen thin beds of volcanic sands and gravels, wind-strewn over an exposed surface before being buried beneath fresh flows. Nowhere were interbedded layers of clay or earthy beds of decomposed rock observed, but such deposits are, I think, exceptional in most basalt areas.

While the gradual building-up of the plateaus from fresh accumulation was steadily in progress, erosion was constantly at work upon the surface; and, although volcanic fires ceased long ago, erosion has been going on steadily ever since. One of the most remarkable and puzzling features of the country are the areas of undoubted water-worn volcanic material, with its smooth and polished bowlders. Accumulations through floods and freshets abound; and, besides the evidence of ancient lakes and ponds found dotted over the surface, there are strong grounds for the belief that upon the upland existed broad rivers which carried the water-laid material across the plateau to the plain below. All this required a long time for its accomplishment.

Turning now to the land vegetation, convincing arguments are found not only for determining the age of the rocks, but for demonstrating that the eruptions lasted throughout a long continued period of activity. It is doubtful if any other known region in the world offers such a promising field of research, showing the relationship between plant life and volcanic eruptions, as is to be found in the Absarokas. In solving these problems the geologist is greatly indebted to the paleobotanist. From time to time extensive collections of fossil plants have been made, indicating a rich and varied flora. Portions of the region have been visited by our distinguished fellow members, Professor L. F. Ward and Professor F. H. Knowlton. All of the collections have been referred to Professor Knowlton, who has made an exhaustive

study of the material, and his researches are now in press. For specific determinations of these plants I refer you to his monograph. Already over 150 species of plants have been identified.

The early acid breccias have yielded a terrestrial vegetation regarded as of earlier age than that obtained from the superimposed lavas. It has furnished a grouping of species so closely allied to the flora found in the Fort Union beds, near the junction of the Yellowstone and Missouri Rivers, that the two floras are regarded as identical in age, and consequently referred to the Eocene period. From these acid breccias eighty species have been identified, and twelve of them were previously only known as belonging to the Fort Union horizon. Still others are common to both localities, but are found elsewhere as well. About one-half of the species are new to science, but according to Professor Knowlton their biological affinities relate them closely to the Fort Union flora. A second grouping of fossil plants, designated for convenience the intermediate flora, flourished at a time when the early acid breccia had about ceased to be emitted; at least they occur near the base of the lower basic breccia in beds indicating a mingling of both types of rock. In all probability they represent a flora which flourished in quiescent times, during a transition period from one series of eruptions to another, but foreshadowing a period of basic eruptions. This flora is of the highest geological significance, since it indicates a great duration of volcanic activity, with a change of climatic and physical conditions. This intermediate flora embraces about thirty species, of which only two or three are as yet known in the acid breccias. About the same number have been recognized as common to the basic breccias, but the evident affinities of the grouping are such that the flora as a whole is apparently more closely allied to the overlying than to the underlying rocks. For this reason it is referred to the base of the Miocene period and is regarded as older than the flora of the auriferous gravels of California.

The vegetation which flourished during the period of the basic breccias was, like the breccias themselves, widely distributed over the mountains wherever mud and silts were present to furnish a suitable soil. Nowhere can it be better studied than at the fossil forest of Specimen Ridge, in the Yellowstone Park, first explored by Professor W. H. Holmes over twenty-five years ago. Since that time other localities have been discovered, and quite recently beds holding leaf impressions of a similar flora have been found on the east side of the mountains. At the fossil forest precipitous walls expose nearly 2,000 feet of horizontal beds of breccias, silts and mud flows, in part laid down by floods and freshets and in part deposited by quiet waters. From base to summit at frequent intervals a terrestrial vegetation has sprung up and flourished, only in turn to be destroyed by renewed lava streams. In one of these buried forests a stump of a still-standing coniferous tree measures 10 feet in diameter and is surrounded by many fallen logs long since preserved by silicification. If one considers the length of time it takes for any vegetation to spring up on an arid lava field and the great age of many of these trees, the time necessary to build up a series of such forests one above another can hardly be overestimated. That there were long periods of rest between the outpourings of the lava seems evident. Throughout this 2,000 feet of erupted material it has been found impossible as yet to discriminate between vegetation found at the base of the cliffs and that interbedded with the lavas at the summit. This implies similar climatic conditions during the time demanded to renew and develop a varied flora between

successive layers of tuffs and muds. It may be well to state that all this probably took place before the period of basalt eruptions. This flora has yielded seventy species, and is regarded as markedly different from that of the earlier breccia, and of later age. As a grouping it shows the closest affinity to the auriferous gravels of California, many of the species being identical, while still others have the closest resemblance to species found only in the gravels. It has been named the Lamar flora, and referred, like the auriferous gravels, to the upper Miocene period. Both the late acid and the late basic breccias have recently yielded well-preserved leaf impressions, proving the existence of a more or less luxuriant flora in all the great periods of breccia eruptions. Such fragmentary material as has been found in these later rocks agrees with plants preserved in the early breccia at Fossil Forest, and, therefore, has been correlated with the Lamar flora of upper Miocene age. It was a vegetation essentially characterized by deciduous foliage. Several species of magnolias, aralias and other equally important groups which are marked features of the auriferous gravels flourished on these volcanic slopes. Specimens of *Aralia notata* occur widely distributed, and the leaves of some of them are supposed to have measured 3 feet in length by 2 in breadth. Associated with them are leaves provisionally referred to the genus *Artocarpus*, indicating the presence of the breadfruit tree. According to Professor Knowlton, this flora is extra-tropical and may be compared in many ways to the vegetation as seen to-day in southern Mississippi and the Gulf coast. He says: "It is obvious that the present flora of the Yellowstone National Park has comparatively little relation to the Tertiary flora and cannot be considered as a descendant of it. It is also clear that the climatic conditions must have greatly changed. The Tertiary flora appears to have originated, or at least to have had its affinities, at the south, while the present flora is evidently of northern origin."

On the slopes of Overlook Mountain, in the center of the range, nearly 11,000 feet above the present sea level, occurs a prostrate log, preserved by silicification, measuring 2 feet in diameter at its base. Not far distant other logs are found, and in the silts occur impressions of deciduous leaves. From this locality four species of plants have been determined as identical with species found in the fossil forest, among them an *Aralia notata*.

In a personal communication Professor Ward informs me that in his opinion the flora of this region grew virtually at sea level. While I recognize his eminent authority in such matters, I am hardly prepared to accept such a radical view, but I cordially welcome this expression of opinion because it in a measure corroborates my own belief that the silts and ashes on which the flora of Overlook Mountain flourished were laid down at a much lower level than that at which they are now found.

Briefly summarizing the facts brought out by a study of the fossil flora and their bearing upon the geology, it is, I think, indisputable that the flora affords abundant evidence of a great range of Tertiary time during the period of volcanic eruptions, even if geologists do hesitate to accept the precise determinations of the age of the different floras and their geological sequence. This luxuriant terrestrial vegetation, developed through thousands of feet of lava beds, tends to confirm the view that the accumulation of this erupted material was an exceedingly slow process. Again, the character of the vegetation lends a forcible argument to the belief that the entire region must have been elevated since the development of so varied an extra-tropical vegetation. For my part, I desire to pay tribute

to the great value of the fossil flora as an aid in deciphering the geological history of the Absarokas. Its interest and importance cannot be overestimated.

Only brief allusions have been made as yet to the intrusive bodies, although they play a most important part in the building-up of the Absarokas. Although such bodies in the form of dikes probably cut the breccias from time to time, it is clearly evident that all the large intrusions, together with the greater part of the dikes, were forced upward and into the breccias at two well-defined periods of eruption. The first of these periods was in part contemporaneous with the early basalt flows, and in part followed them. The second followed the late basic breccia and basalts, and, so far as can be told, completed the final chapter in the geological history of the immediate region. It is possible that later eruptions took place and that the material ejected was removed by erosion, but of this there is no positive record other than a few isolated patches of rhyolite which do not bear directly upon the problems before us and which may be regarded as outliers of the rhyolite of the Park plateau. It does not follow that the intrusions of either period were contemporaneous in age, but simply that they belong to a certain phase of the eruptive energy. Dikes may cut an earlier series of intrusives, and subsequently other dikes may intersect those which preceded them.

For the purpose of clearly discriminating between these two groups of rocks, the one that followed the early basic breccia has been named the Sunlight intrusives, from their remarkable exposures along Sunlight Creek and valley, while the later group has been named the Ishawooa intrusives, from the canyon of that name, where the complexity of their occurrences forms one of the most striking features of that impressive gorge. In mineral composition the Sunlight intrusives range from a quartz-augite-andesite, through transition forms of syenite and diorite, to orthoclase-gabbro. The large body at the head of Sunlight Creek is mainly a syenite with associated monzonites and diorites. On Closed Creek, in Crandall Basin, the intrusive body consists for the most part of orthoclase, gabbro and diorite. The series as a whole shows an association of the minerals augite, plagioclase and orthoclase, with quartz and biotite in its more siliceous members, and olivine and hypersthene in its basic members. In general, the Sunlight intrusives are more diversified in chemical composition than those of the Ishawooa group. The latter are more siliceous, carrying less of magnesia and alkalies, and the coarsely crystalline masses are much more like normal diorite, diorite-porphyry, granite, granite-porphyry and andesite-porphyry.

Of the Sunlight intrusive bodies the one situated near the source of Sunlight Creek, in the central portion of the range, is the most impressive, and at the same time the most typical in its occurrence. It measures nearly 3 miles in length and occupies the basins of all the deep glacial amphitheatres on the north side of Stinkingwater River, while all the high intervening ridges separating the basins consist of indurated breccia. Similar rocks are exposed in the Silvertip Basin, on the south side of the peak, and in all probability they form part of one continuous body.

The Crandall Basin stock, under Hurricane Mesa, exposed by the erosion of Closed Creek, has far less lateral expansion, but rises for nearly 3,000 feet above its base. Dikes radiate from all the large intrusive bodies, but nowhere else is their number so great and the part they play so strongly marked as in the region of the Sunlight stock. These dikes are by no means all connected with the large stocks seen at the surface, but may be observed in

great force at a number of localities in the early breccia along the east side of the range, far removed from any recognized crystalline body. Wherever these early breccias occur dikes are apt to be a marked feature of the country, in contradistinction to the country occupied by the latter breccias.

These dikes consist mainly of orthoclase basalts, which Professor Iddings, from his microscopical studies, has divided into absarokites, shoshonites and banakites, depending upon their varying mineral and chemical composition. In the field it seems impossible as yet to differentiate between them, and so far as can be told they present the same mode of occurrence. For most geological purposes they may be grouped together under the general term of absarokites. They form a connecting link between many of the eruptions in the early basalt sheets and the Sunlight intrusives. They are closely related to the syenites and monzonites of the Sunlight intrusive stock. Both these dikes and sheets occur over extensive areas.

Leaving for the present the Sunlight intrusives, let us take up the Ishawooa intrusives, which I select in order the more easily to bring out in detail certain facts bearing upon the origin of both types of intrusive rocks. Of the many intrusive bodies, Needle Mountain, in the southern end of the Absarokas, is the most imposing and instructive of them all. At the base runs the Shoshone River, through one of the most rugged and picturesque canyons to be found in northern Wyoming. This great stock, which stretches along the valley for nearly four miles, rises abruptly 4,000 feet above the stream bed, from an elevation of 7,000 feet above sea level. It is overlain by 1,000 feet of partially indurated and metamorphosed breccia. From the rounded summit of this commanding peak the breccias may be seen stretching far to the west on the opposite canyon wall, thence across Thoroughfare Plateau and on to the higher regions of Wind River Plateau, where they lie nearly horizontal at an elevation approximately the same as that of Needle Mountain itself. Upon this latter plateau the Shoshone River finds its sources, and in its rapid descent of 5,000 feet before reaching Needle Mountain exposes large, irregular stocks of indefinite outline piercing the breccias.

Looking eastward from Needle Mountain, the breccias extend as far as the eye can reach in the direction of the broad, open plain beyond. The massive stock of Needle Mountain consists essentially of diorite, quartz-diorite and diorite-porphyry, cut by numerous narrow dikes of apparently differentiated products of the same molten magma. Offshoots and apophyses from the parent stock pierce the surrounding breccia, and a number of small dikes penetrate the overlying breccia. From these dikes sheets of granite-porphyry stretch out into the breccias, and on the spurs of the mountain erosion has worn them bare, leaving them exposed as the surface rock. The stock is found on the opposite side of the canyon, rising high above the stream and capped by the ever-present breccia. Bordering the diorite stock the breccias are indurated, crushed, and so altered that not infrequently it is impossible to discriminate between breccias and intrusive stocks without the aid of the microscope. Dr. Jaggar has shown that many of these fine-grained rocks are altered mud and silts and metamorphosed breccias.

From Needle Mountain to Mount Chittenden, in the Yellowstone Park, a distance of over fifty miles, there extends in a northwest direction a remarkable and probably a continuous belt of intrusive rocks. These intrusive bodies occur as stocks, sheets, bosses and dikes, varying from irregular-shaped masses of stupen-

dous proportions, two and three miles in width and several thousand feet in height, to narrow dikes and seams traceable along the canyon walls for only a few feet and often disconnected at the surface from any other body. A short distance north of Needle Mountain, but on the opposite side of the canyon, another great stock rises precipitously above the stream bed, and it is clearly evident that its relation to the breccias are in every way similar to those observed at Needle Mountain. Between these two massive bodies smaller outcrops of diorite and diorite-porphyry are exposed in lateral ravines on the mountain sides, and the network of dikes trending in every direction points conclusively to the fact that these intrusive bodies belong to one and the same stock. Dislocated and indurated bodies of breccia are found upon the mountain spurs, but the overlying capping of breccia peacefully crowns it all.

From this point northward, following along the line of the powerful intrusions, each dissecting canyon, where it cuts the intrusive masses, lays bare numerous exposures of crystalline rocks which have forced their way upward into the breccias, and, following lines of least resistance, have spread out in all directions with a marvelous complexity of form and outline. Some of the stocks penetrating the breccia have attained elevations slightly above the present level of the plateau, but most of them failed to reach so high a position. Wherever they have reached the top of the plateau their tendency is to spread out in sheets, which now form the exposed surface of spurs and ridges. Many of these interbedded sheets are directly connected with some of the larger stocks, but others show no such relationship at the surface and stand out quite independently of them. Occasionally the sheets bulge up with irregular outline; others are dome-shaped, developing laccolithic form. Vertical dikes cutting the interbedded breccias pass into sheets, and later again assume the conditions of normal vertical dikes. The variable character of the breccia, sometimes compact and uniform and at others made up of an incoherent mass of silts and ash, tends to constant change in the upward movement of the molten magma.

The gorges of both Cabin Creek and Canyon Creek expose similar rocks, with accompanying phenomena of strain and rupture. Ishawooa Canyon, one of the most rugged of these incisive trenches, presents varied modifications of eruptive energy, a bold stock, Clouds Home, piercing the breccias with an irregular outline from the bottom of the canyon to the top of the plateau. One of the finest examples of a massive interbedded sheet extends for a mile or more along the canyon wall. Similar phenomena present themselves in Wapiti Canyon, where four tributary streams, uniting to make the river, have cut down in the intrusive masses in a most instructive manner. Near the sources of Eagle Creek diorite and andesite-porphyry are again laid bare, and thence, trending across the crest of the range, extend as far as Sylvan Pass, where coarsely crystalline diorite and diorite-porphyries come to the surface for the last time in an exposure nearly a mile in length. Beyond this point eruptive energy gradually dies out, and is only shown by the presence of a few powerful dikes noticeable for their uniformity and persistency.

A distinctive feature along this entire line of intrusive rock is the belt of indurated breccia which accompanies it. Near the larger stocks the alteration of the breccia is especially noticeable, and not infrequently it is difficult to discriminate between the stock masses and the metamorphosed material. The mode of weathering is so unlike that of the ordinary breccia,

and the transitions are so gradual, that it is by no means easy to define the outlines of the intrusive masses without personal inspection. Although never having been followed as a continuous body, owing to the nature of the topography, the zone of induration is one of the marked features of the region, and under favorable conditions may be traced in the canyon walls for fifty miles, with a width in places of more than one-half mile. Another important and significant feature is the inclination of the breccias away from some well-defined axis or central ridge. They do not as a rule arch over any single powerful protrusion, but present every indication of a broad anticlinal structure, with the piled-up lavas inclined toward the west and southwest on one side and toward the east and northeast on the other. Between the more massive bodies that have been forced upward to elevations above the general level there may be found areas of indurated breccia, traversed by a labyrinth of dikes and veins in their efforts to force their way upward.

Without entering into petrographic details, a few words in addition to what has already been said seem necessary. Granites and diorites are seldom met with other than in connection with the large uniform stocks. As most of these stocks are only partially exposed, their volume can only be a matter of conjecture, but in all the larger bodies, such as Needle Mountain, the rock is essentially that of a medium-grained diorite or diorite-porphyry. A true granitic structure is by no means uncommon. Most of the powerful intrusions, as regards their crystalline structure, may be classed as granular. The great bulk of these crystalline rocks apparently carry some little groundmass. Porphyritic structure, with little groundmass, is a characteristic feature, with transitions into andesite-porphyry and andesite. Many similar bodies of indefinite outline, only partially exposed by erosion of the canyon walls, are andesites. Indeed, all the relatively small bodies are andesitic in habit, and the same is true of the many outlying bodies away from the general northwest-southeast trend of the intruded rocks.

A field study of these rocks of varying degrees of crystallization shows clearly that they were all exposed to virtually the same degree of pressure of overlying rock, and that their structural differences were not dependent primarily upon pressure from above. Many of these andesitic masses are much smaller than the diorite bodies and occur at much lower levels below the superimposed load. All observations upon the geological relations of these intrusives to the breccias tend to show that their structural differences are dependent far more upon the chilling effect of the surrounding rock and the rate of cooling than upon the pressure of the overlying rock. Geologists and petrographers have been for a long time investigating the structural differences and mineral variations of igneous rocks. Of these philosophical investigators Professor Iddings stands in the foremost rank. In an exhaustive petrographic study of the Crandall Basin intrusive body and its complex system of radial dikes of varying composition he reaches the conclusion that they have all been derived from the same parent molten magma, but crystallized under different conditions. With this conclusion I heartily agree. Dr. Jaggar, who has been at work upon a petrographical study of the intrusive rocks of the rest of the Absaroka Range, has reached a similar conclusion as regards the Ishawooa intrusive stock and associated sheets and dikes, and believes that they were derived from a common molten magma, which is quite in accord with geological observations in the field. From these observations, thus briefly and imperfectly stated, the conclusion seems inevitable that the Ishawooa intrusive, for its entire length of fifty

miles, represents a continuous ridge, the result of the consolidation of a molten magma intruded into the breccias. Erosion has as yet laid bare only the more elevated portions and some of the connecting links.

If a trained geologist were to stand on any one of the more prominent points in the Absarokas his attention would, first of all, be attracted by the vast amount of fragmental ejectamenta lying with apparent horizontality in every direction. Closer observation would impress him with the bedded nature of much of this material and the action which running water had played in disintegrating the lava and rounding the andesitic and basaltic bowlders. If, by chance, he had acquainted himself with the huge stocks exposed in the canyons, knowing the power of dense crystalline rocks to withstand atmospheric agencies better than the easily disintegrating breccias, he would be surprised to find that none of the larger ones towered above the plateau in commanding peaks. At one or two localities they attain the present level of the plateau, but do not rise much above it, and usually give evidence of the dying out of the energy which forced the magma upward. As these intrusive stocks are overlain by breccia sometimes 1,000 feet in thickness, it is difficult to see how they ever could have been centers of powerful extrusive eruption.

In an address delivered before the British Association for the Advancement of Science in September, 1893, Professor Iddings took the ground that the Crandall Basin stock was the core of a grand volcano, from which issued the breccias, silts and tuffs which have built up the north end of the range, while the gabbros and diorites represent the coarsely crystalline development of that portion of the magma which cooled at great depths beneath the surface. He reconstructed a volcano to a height of 10,000 feet above the plateau, and subsequently removed by erosion every vestige of the volcano down to the summit of Hurricane Mesa, the present level of the plateau. He likens it, in magnitude and in the processes by which it was built up, to the volcanoes of Ætna and Vesuvius. An abstract of the address was published in the *Journal of Geology* for September and October, 1893, and in a forthcoming report on the geology of the Yellowstone National Park a detailed description of the Crandall stock will be found, together with the results of his admirable petrographic studies of the rocks, to which allusion has already been made. After what has been said, it seems hardly necessary to add that with these geological views of Professor Iddlings I do not agree. My interpretation of the history of this region may possibly call forth the friendly criticism that this address is an account of the early Tertiary volcanoes of the Absarokas with the volcanoes left out. For such criticism there may be some slight ground; but, while I fail to see any evidence of the building-up of such volcanic piles as Vesuvius and Ætna, or, as I should prefer to put it, volcanoes of the type of Rainier, Hood or Shasta, there was displayed intense explosive energy accompanied by immense volumes of steam and the piling-up of a vast block of lavas from many centers of activity. Instances of such explosive energy may be seen at Chaos Mountain, but the material thrown out yielded readily to atmospheric agencies and soon became spread out over the entire region. The whole area of the late acid breccia suggests several powerful vents for the ejectment of fragmental material and the partial wearing-away of mounds and ridges of the heaped-up accumulations. It is possible that before the Sunlight and Ishawooa intrusives were forced upward volcanoes existed, but that any one or two of them dominated the region and influenced the topographical configuration of the Absarokas is exceedingly doubtful. There is noth-

ing to indicate the characteristic slopes of a great volcano.

Within the Yellowstone Park and just west of the Absarokas occurs a fine example of a volcano, situated near the intersection of the prolongation of the Ishawooa intrusive body and the fault along the southern slope of the Snowy Range. Mount Washburne is the culminating point of the volcano, which consists almost wholly of fragmental early basic breccia. From a well-recognized crater, since partially filled with rhyolite, the erupted material has been thrown out in every direction, building up true volcanic slopes encircling a central discharging vent. Such a structure I have never been able to recognize in the Absarokas. Mount Sheridan, in the Park, is another large volcano, but this is a Pliocene eruption consisting wholly of rhyolite, and is one of the sources of the great body of rhyolite which built up the Park plateau probably long after the Absarokas ceased to be a center of volcanic action.

Of all known regions of eruptive energy within historical times, Iceland in many ways affords the best field for comparison of the volcanic phenomena of to-day with conditions as they existed during the early Tertiary time in the Absarokas. Iceland is one of the active centers of eruption on a stupendous scale. It offers a continuous volcanic history throughout Pleistocene time, and dates back to the early Miocene, as is indicated by its fossil flora. In early Tertiary time the island was a region of profound faulting, and it is supposed to have been separated from the mainland during that period. Dr. Thoroddsen, the Icelandic geologist, has published in European scientific journals most interesting accounts of his explorations over the less-known regions of the island. The most complete and instructive of these accounts which has come to my attention was published by the Stockholm Society of Science in 1888. Notwithstanding the volcanoes of majestic proportions which contribute so much to the scenic grandeur of Iceland, and which must give to all geologists who have seen them a profound sense of the power of volcanic energy, Dr. Thoroddsen, who has lived among them, protests against the idea that they were built up like Vesuvius or Ætna. He says: "The vast lava waste of Odadahraun was produced by the eruption of over twenty volcanoes, and perhaps many of the oldest centers of eruption that contributed to the formation of this desert have become obliterated by later lava streams. When one recalls geological text-book descriptions of modern volcanoes and their activity, it is nearly always Vesuvius that everywhere turns up like a spectre, whereas the regular volcanic cone composed of alternating lavas and tuffs is rather rare in Iceland."

The country which he is describing may be about one-half the size of the Absaroka Range, but I have no maps or accurate data for determining the area. Again, later, he says: "Only a few old volcanoes are found having this form. In Iceland it is very generally found that the fissure has not given rise to the formation of any real volcano. The lava there has sometimes welled out along the entire length of the fissure without the formation of a crater, but mostly there has been formed a series of low slag cones at the points where the magna, by reason of the form of the fissure or for some other cause, found it easiest to break forth. Such rows of craters are found in all volcanic regions of Iceland." Another noticeable feature, even in the active regions of Iceland, is the ease with which sources of eruption may become obliterated by fresh flows from neighboring vents of discharge. According to Dr. Thoroddsen the famous Heckla itself is a long ridge built up by a chain of small craters along a line of fissure.

Sir Archibald Geikie, in his admirable

work on the Ancient Volcanoes of Great Britain, in comparing the volcanic phenomena of the Icelandic eruptions with those exhibited by the basalt plateaus of the British Isles, remarks: "It is, therefore, to the Icelandic types of fissure eruption, and not to great central composite cones, like Vesuvius or Ætna, that we must look for the modern analogies that would best serve as commentary and explanation for the latest chapter in the long volcanic history of the British Isles."

In comparing volcanic areas of Iceland with the phenomena exhibited in the Absaroka Range there is one striking difference to be noted. In the former the extravasated molten magma consists largely of basaltic flows, while in the latter one is constantly impressed by the enormous amount of brecciated rock emitted. It is estimated that four-fifths of these extrusive rocks which make up the range consist of coarse and fine breccias, silts and related ejectamenta. Dead Indian Peak, one of the dominating points of the range, rises more than 6,000 feet above the valley, presenting layers of breccia which in the aggregate measure nearly one mile in thickness. It is a very conservative estimate to place the volume of breccia at one-half mile in thickness over the entire region under discussion, which, it should be remembered, embraces not much less than 4,000 square miles. This only allows for erosion an amount equal to the highest plateau summit, but it is sufficient to give one an idea of its vast bulk. That the denudation from the top of the existing plateau was very considerable is unquestioned, but there exist, I think, no reliable data upon which to base even an approximate estimate of the amount. Possibly the country was at one time covered with a mantle of basalt, which, withstanding erosion, would, of course, protect the friable volcanic material throughout a long period.

It is evident that the granular rocks required for their uniform crystallization an overlying load of greater or less depth. For my own part, I am more or less skeptical as to the need of an immense thickness of overlying material to develop such uniform consolidation as is generally supposed to be necessary to produce the so-called plutonic rocks. At Needle Mountain the medium-grained granular diorite for the entire 4,000 feet of rock face is apparently the same throughout, whereas only a short distance from the mass and at a lower level small bodies of rock in cooling have developed a characteristic andesitic structure.

It must be borne in mind that all this material, of varied mineral composition, grouped together under the designation of breccias, was congealed and crystallized before it was hurled out by explosive action. This means stupendous crushing and crunching of the mass as it was forced upward, and disturbances of the first magnitude, which must have had their origin in great crustal movements. Whence came this enormous mass of brecciated rock? Twice during the long period of their eruptions these breccias had been invaded by enormous bodies of granular rock which had elevated the entire Absaroka Range, an elevation that was phenomenal in its nature and formed a part of the great series of orogenic movement which uplifted the northern Cordillera. This uplift was closely related to the post-Laramie movement, which was one of the most profound and far-reaching orogenic disturbances anywhere recognized by geologists.

Throughout this address the large individual protrusions into the breccia have been alluded to as stocks, but I regard them as the more elevated portions of a great complex of crystalline rocks underlying at least a large part of this region of country. Where the underlying molten magma was subjected to the severest pres-

sure the material was squeezed upward to higher levels, following lines of least resistance, and consolidated at greater or less depths beneath the surface. This upward movement was probably coincident with the crustal movements that elevated the entire Absaroka Range. The line of Ishawooa intrusives marks the trend of one such upward movement of molten magma, which for the most part congealed without finding egress to the surface. That a portion of the magma may have been pushed upward through fissures and vents and discharged as surface flows of andesite is possible, but of such flows, if they existed, no positive evidence remains.

Conditions somewhat similar to those found in the Absarokas are described by Professor Adolph Stelzner as occurring in the Andes of Argentina. He describes granites, diorties and syenites as penetrating the andesitic tuffs and lavas of Tertiary age, and as cooling under a heavy load of superimposed material. He does not regard these massive crystalline bodies as conduits of volcanoes, but as large stocks formed independently of such vents. He refers to them as taking part in the great orogenic uplift which elevated the Cordillera of South America, an uplift which began in Jurassic time, lasted through the Mesozoic, and continued through the greater part of the Tertiary.

In the discussions of volcanic phenomena found throughout geological literature, circular vents of great depth seem to be regarded as indispensable and are supposed to furnish an open door for the molten magmas, permitting them to take a straight shoot from the eternal depths to daylight. In this way geologists certainly avoid many perplexing physical problems which confront us in the case of stocks and laccoliths penetrating sedimentary rocks and stopping far short of the surface. In speaking of areas of igneous rocks, one almost hesitates to use the term laccoliths, so universally is it referred to in its relation to sedimentary rocks. For my part, it seems far more reasonable to look for such intrusive bodies in areas of igneous rock than in regions of sedimentation. That large intrusive bodies came to a standstill without any surficial manifestations, in the Absarokas, is, I think, fairly well determined.

Two years ago it was my good fortune to cross the Cascade Range at a number of localities and to climb far above timber line the slopes of Mount Rainier, in Washington; Mount Hood, in Oregon, and Mount Shasta, in California. From these commanding points comprehensive panoramic views were obtained over a broad field of igneous rock. Majestic and impressive as are these volcanoes, and grand in their isolation, I could but feel that back of them all lay earlier chapters in the Tertiary history of volcanic energy on the Pacific side of the Cordillera; that these powerful volcanoes were but a late expression of the intensity of the eruptive energy, and that still earlier volcanic masses had in some way taken part in the orogenic disturbances of an earlier Tertiary time. So, on the east side of the great Cordillera, the early Tertiary fires long since ceased to glow in the Absarokas, and the center of volcanic energy moved westward and built up on different lines the broad rhyolite plateau of the Yellowstone Park, a plateau strongly contrasted with the Absarokas in the almost entire absence of breccias. The work of such investigators as Emmons and Cross in Colorado and Weed and Pirsson in Montana is slowly but surely solving the problems of the post-Cretaceous uplift in the northern Cordillera, and, it will, I think, finally be shown that the crystalline rocks consolidated below the surface have played an important part in bringing about the Cordilleran revolution.

On a bright crisp autumnal day in 1897 I left the Absarokas by the way of that

most interesting of valleys, Clark's Fork of the Yellowstone, still impressed with the many unsolved problems connected with the geology of the range. I at first visited the region in the expectation of finding a partially submerged range of Paleozoic and Mesozoic sediments. If ever such range existed, it had completely disappeared by profound subsidence. I then looked for the roots of some powerful dominating volcano which had been the source of the varying breccias, but this also I failed to discover. In its stead, if I interpret the facts correctly, I found penetrating the breccias the towering domes and pinnacles of granular and porphyritic rocks, which in some far-distant day, when denudation has removed a greater part of the overlying mass, may be found to form one connected body which erosion has already so far laid bare as to indicate that they all form a part of one broad complex of coarsely crystalline rock of early Tertiary age.

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*THE PHYSIOLOGICAL BASIS OF MENTAL LIFE.**

If we demand a physiological process corresponding to every possible variation of the content of consciousness the structure of the brain seems far too uniform to furnish a sufficient manifoldness of functions. The mere number of elements cannot be decisive; if they are all functionally coordinated they can offer merely the basis for coordinated psychical functions. If we have psychical functions of different orders it would not help us even if we had some millions more of the uniform elements. It would be useless to deny that here exists a great difficulty for our present psychology; the only question is whether this difficulty really opposes the demands and suppositions of psychophysical parallelism or whether it means that the usual theories of to-day are inadequate and must be improved. It seems to me that the latter is the case, and that hypotheses can be constructed by which all demands of psychology can be satisfied without the usual sacrifice of consistency. The situation is the following:

The whole scheme of the physiologists operates to-day in a manifoldness of two dimensions: they think the conscious phenomena as dependent upon brain excitements which can vary firstly with regard to their localities and secondly with regard to their quantitative amount. These two variations then correspond to the quality of the mental element and to its intensity. In the acoustical center, for instance, the different pitch of the tone sensations corresponds to locally different ganglion cells, the different intensities of the same tone sensation to the quantity of the excitement. Association fibers whose functions are not directly accompanied by conscious experiences connect these millions of psychophysical elementary centers in a way which is imagined on the model of the peripheral nerve. No serious attempt has been made to transcend this simple scheme. Certainly recent discussions have brought many propositions to replace the simple physiological association fiber which connects the psychophysical centers by more complicated systems—theories, for instance, in regard to the opening and closing of the connecting paths or in regard to special association centers or special mediating cell groups—but these and others stick to the old principle that the final psychophysical process corresponds to the strength and locality of a sensory stimulation or of its equivalent reproduction, whatever may have brought about and combined the excitements.

It is true that it has been sometimes suggested that the same ganglion cell may go

*Read before the joint meeting of the Psychological Association and the Physiological Society.

over also into qualitatively different states of excitement, and thus allow an unlimited manifoldness of new psychophysical variations. But it is clear that to accept such an hypothesis means to give up all the advantages of brain localization. The complicatedness of the cell would be in itself sufficient to give ground to the idea that its molecules may reach some millions of different local combinations, and if every new combination corresponds to a sensation all the tones and colors and smells and many other things may go on in one cell. But, then, it is, of course, our duty to explain those connections and successions of different states in one cell, and that would lead to thinking the cell itself as constructed with millions of paths just like a miniature brain; in short, all the difficulties would be transplanted into the unknown structure of the cell. If we, on the other hand, do not enter into such speculations the acceptance of qualitive changes in the cell would bring us to the same point as if we were satisfied to speak of qualitative changes of the brain in general. It would not solve the problem, but merely ignore it, and, therefore, such an additional hypothesis cannot have weight.

The only theory which brings in a really new factor is the theory of innervation feelings. This well-known theory claims that one special group of conscious facts, namely, the feelings of effort and impulse, are not sensations and, therefore, not parallel to the sensory excitements, but are activities of consciousness and parallel to the physiological innervation of a central motor path. At this point, of course, comes in at once the opposition of the philosophical claim that every psychical fact must be a content of consciousness, and made up of sensations, that is, of possible elements of idea, to become describable and explainable at all. The so-called active consciousness, the philosopher must hold, has nothing to do with an activity of the consciousness itself, as consciousness means, from the psychological standpoint, only the kind of existence of psychical objects. It cannot do anything, it cannot have different degrees and functions, it only becomes conscious of its contents, and all variations are variations of the content, which must be analyzed without remainder into elements which are theoretically coördinated with the elements of ideas, that is, with the sensations, while consciousness is only the general condition for their existence. But also the empirical analysis and experiment of the practical psychologist are in this case in the greatest harmony with such philosophical claims and opposed to the innervation theory. The psychologist can show empirically that this so-called feeling of effort is merely a group of sensations like other sensations, reproduced joint and muscle sensations which precede the action and have the rôle of representing the impulse merely on account of the fact that their anticipation makes inhibitory associations still possible. It would thus from this point of view also be illogical to think the psychophysical basis of these sensations different in principle from that of other sensations. If the other sensations are accompaniments of sensory excitements in the brain the feelings of impulse cannot claim an exceptional position.

But are quality and intensity really the only differences between the given sensations? Can the whole manifoldness of the content of consciousness really be determined by variations in these two directions only? Certainly not; the sensations can vary even when quality and intensity remain constant. As an illustration we may think, for instance, of one variation which is clearly not to be compared with a change in kind and strength of the sensation; namely, the variation of vividness. Vividness is not identical with intensity; the vivid impression of a weak sound and the

unvivid impression of a strong sound are in no way interchangeable. If the ticking of the clock in my room becomes less and less vivid for me the more I become absorbed in my work, till it finally disappears, it cannot be compared with the experience which results when the clock to which I give my full attention is brought farther and farther away. The white impression, when it loses vividness, does not become gray and finally black, nor the large size small, nor the hot lukewarm. Vividness is a third dimension in the system of psychical elements, and the psychologist who postulates complete parallelism has the right to demand that the physiologist show the corresponding process. There are other sides of the sensation for which the same is true; they share with vividness the more subjective character of the variation, as, for instance, the feeling tone of the sensation or its pastness and presentness. Other variations bring such subjective factors into the complexes of sensations without a possibility of understanding them from the combination of different kinds only; for instance, the subjective shade of ideas we believe or the abstractedness of ideas in logical thoughts. In short, the sensations and their combinations show besides kind, strength and vividness still other variations which may best be called the values of the sensations and of their complexes. Is the typical theory of modern physiological psychology, which, as we have seen, operates merely with the local differences of the cells and the quantitative differences of their excitement, ever able to find physiological variations which correspond to the vividness and to the values of the sensations?

An examination without prejudice must necessarily deny this question. Here lies the deeper spring for the latent opposition which the psychophysiological claims find in modern psychology. Here are facts, the opponents say, which find no physiological counterpart, and we must, therefore, acknowledge the existence of psychological processes which have nothing to do with the physiological machinery. The vividness, for instance, is fully explained if we accept the view that the brain determines the kind and strength of the sensation, while a physiologically independent subject turns the attention more or less to the sensation. The more this attention acts the more vivid the sensation; in a similar way the subjective acts would determine the feeling tone of the sensation by selection or rejection, and so on. While the usual theory reduces all to the mere association of locally separated excitements, such a theory thus emphasizes the view that the physiologically determined functions must be supplemented by an apperceiving subject which takes attitudes. We may call the one the association theory, the other the apperception theory. We have acknowledged that the association theory is insufficient to solve the whole problem, but it is hardly necessary to emphasize that the apperception theory seeks the solution from the start in a logically impossible direction, and is thus still more mistaken than the association theory.

The apperception theory, whatever its special label and make-up may be, does not see that the renunciation of a physiological basis for every psychical fact means resigning the causal explanation altogether, as psychical facts as such cannot be linked directly by causality, and that resigning the causal aspect means giving up the only point of view which comes in question for the psychologist. If those apperceptive functions are seriously conceived without physiological basis they represent a manifoldness which can be linked merely by the teleological categories of the practical life, and we sink back to the subjectifying view which controls the reality of life, but which

is in principle replaced by the objectifying view as soon as the experience of the subject is acknowledged as a series of psychological objects.

But does this bankruptcy of all varieties of apperception theories necessarily force us back to the association theory? I do not think so. The demand of the association theory that every psychosis should be accompanied by a neurosis cannot be given up, but this neurosis may be thought in a richer way than in the scheme of the associationists. It seems to me, indeed, that the physiological theory works to-day with an abstract scheme with which no observation agrees. We do not know of a centripetal stimulation which does not go over into centrifugal impulses. The studies on tonicity and actions of voluntary muscles, on the functions of glands and blood vessels, on tendon reflex centers, and so on, show how every psychophysical state discharges itself into centrifugal functions. And yet these perceivable peripheral effects are, of course, merely a small part of the centrifugal impulses which really start from the end stations of the sensory channel, as most of them probably produce only new dispositions in lower motor centers without going directly over into movement, and others may fade away in the unlimited division of the discharge in the ramification of the system. Those milliards of fibers are not merely the wires to pull a few hundred muscles; no, the centrifugal system represents certainly a most complex hierarchy of motor centers too, and the special final muscle impulse is merely the last outcome of a very complex cooperation of very many factors in the centrifugal system. Manifold as the incoming nerve currents must be, thus, also the possibilities of centrifugal discharge, and the dispositions in the nervous motor system determine the degrees in which the ganglion cells can transform the centripetal into centrifugal stimulation. It is thus not only the foregoing sensory process, but in exactly the same degree also the special situation of the motor system, its openness and closedness, which governs the process in the center. Whether the special efferent channel is open or plugged implies absolutely different central processes in spite of the same afferent stimulus.

Here we have, then, a new factor on the physiological side which is ignored in the usual scheme that makes the psychical facts dependent upon the sensory processes only and considers the centrifugal action of the brain as a later effect which begins when the psychophysical function is over. There is no central sensory process which is not the beginning of an action too, and this centrifugal part of the central process necessarily varies the accompanying psychical fact also. As here the action of the center becomes the essential factor in the psychophysical process, we may call this view an action theory as over against the association and apperception theories of the day. The action theory agrees, then, with the associationism in the postulate that there is no psychical variation without variation on the physiological side and with the apperceptionism in the conviction that the mere association of sensory brain processes is insufficient to play the counterpart to the subjective variation of the psychical facts as vividness and values of the sensations. It tries to combine the legitimate points in both views, and claims that every psychical sensation as element of the content of consciousness is the accompaniment of the physical process by which a centripetal stimulation becomes transformed into a centrifugal impulse.

This central process thus clearly depends upon four factors: firstly, upon the local situation of the sensory track; secondly, upon the quantitative amount of the incoming current; thirdly, upon the local situation of the outgoing discharge; and

fourthly, upon the quantitative amount of the discharge. The first two factors are, of course, determined by the incoming current, which can be replaced by an intracortical stimulation from an associated center, while the last two factors are determined by the dispositions of the centrifugal system. The association theory, which considers the first two factors alone, thinks them parallel to the kind and strength of the sensation. The action theory accepts this interpretation and adds that the two other factors determine the values and the vividness of the sensation—the values parallel to the local situation of the discharge, the vividness to the openness of the centrifugal channel, and thus to the intensity of the discharge.

If the centrifugal discharge is inhibited, the channel closed, then the sensory process goes on as before, but the impression is unvivid, unperceived, while it may become vivid later as soon as the hindrance of the discharge disappears. The inhibition of ideas which remains unexplainable to the associationists would then mean that a special path of discharge is closed, and thus the idea which needs that discharge for its vividness cannot come to existence; the hypnotizer's words, for instance, close such channels. Only discharges, actions, can be antagonistic and thus under mutual inhibition; ideas in themselves may be logically contradictory, but not psychologically, while one action makes the antagonistic action, indeed, impossible, and the inhibition of ideas results merely from the inhibition of discharges. If this view is correct it is clear that while we strictly deny the existence of special innervation sensations we can now say that every sensation without exception is physiologically an innervation sensation, as it must have reached some degree of vividness to exist psychologically at all.

With regard to the local situation of the motor discharge the manifoldness of possibilities is evident. The channels may be closed in one direction, but open in others; the actually resulting discharge must be the product of the situation in the whole centrifugal system, with its milliards of ramifications, and the same sensory stimulus may thus under a thousand different conditions produce a thousand different centrifugal waves, all, perhaps, with the same intensity. The vividness would then be always the same, and yet the difference of locality in the discharge must give new features to the psychical element. A few cases as illustrations must be sufficient. We may instance the shades of time-direction; the same idea may have the subjective character of past, present and future. It corresponds to three types of discharge: the discharge which does not include action on the object any more appears as past; that which produces action as present, and that which prepares the action as future. In this group belong also the feeling tones: the pleasurable shade of feeling based on the discharge towards the extensors; the unpleasant feelings based on the innervation of the flexors. Here belong the differences between mere perception and apperception, as in the one case the discharge is determined by the impression alone, in the other case by associations also. Here belong the characteristics of the abstract conception which may be represented by the same sensational qualities which would form a concrete idea and yet has a new subjective tone because the centrifugal discharge is for the concrete idea a specialized impulse, for the conception a general impulse which would suit all objects thought under the conception. Here belongs, also, the feeling of belief which characterizes the judgment; the judgment differs psychophysically from the mere idea in the fact that the ideas discharge themselves in a new tonicity, a new set of the lower motor centers, creating thus a new

disposition for later reactions. To be sure, many of these discharges lead finally to muscle contractions which bring with them centripetal sensations from the joints, the muscles, the tendons, and these muscle and joint sensations themselves then become a part in the idea, for instance, of time, of space, of feeling. But the new part only reinforces the general tone which is given in the general discharge, and gives to it only the exact detail which gets its character just through the blending of these sensations of completed reactions with the accompaniments of the central discharge.

A consistent psychology thus may start with the following principles: It considers all variations of mental life as variations of the content of consciousness, and this content as a complex object, including in this first presupposition a complicated transformation of the real inner life, a transformation by which the subjectifying view of real life is denied for the causal psychological system. Every content of consciousness is further considered as a complex of sensations, that is, of possible elements of perceptive ideas. Every sensation is considered as having a fourfold manifoldness, varying in kind, in strength, in vividness and in value. The physiological basis of every sensation, and thus of every psychical element, is the physical process by which a centripetal stimulation becomes transformed into a centrifugal impulse, the kind depending upon the locality of the centripetal channel, the strength upon the quantity of the stimulus, the value upon the locality of the centrifugal channel, and the vividness upon the quantity of the discharge.

HUGO MÜNSTERBERG.
HARVARD UNIVERSITY.

SOPHUS LIE.

ON the eighteenth of February, 1899, the greatest mathematician in the world, Sophus Lie, died at Christiania in Norway.

He was essentially a geometer, though applying his splendid powers of space creation to questions of analysis. From Lie comes the idea that every system of geometry is characterized by its group. In ordinary geometry a surface is a locus of points; in Lie's *Kugel-geometrie* it is the aggregate of spheres touching this surface. By a simple correlation of this sphere-geometry with Pluecker's line-geometry, Lie reached results as unexpected as elegant. The transition from this line-geometry to this sphere-geometry was an example of contact-transformations.

Now contact-transformations find application in the theory of partial differential equations, whereby this theory is vastly clarified. Old problems were settled as sweepingly as new problems were created and solved.

Again, with his *Theorie der Transformationsgruppen*, Lie changed the very face and fashion of modern mathematics.

A magnificent application of his theory of continuous groups is to the general problem of non-Euclidean geometry as formulated by Helmholtz. To this was awarded the great Lobachévski Prize. Not even this award could sufficiently emphasize the epoch-making importance of Lie's work in the evolution of geometry.

Moreover, the foundations of all philosophy are involved. To know the non-Euclidean geometry involves abandonment of the position that axioms as to their concrete content are necessities of the inner intuition; likewise abandonment of the position that axioms are derivable from experience alone.

Lie said that in the whole of modern mathematics the weightiest part is the theory of differential equations, and, true to this conviction, it has always been his aim to deepen and advance this theory. Now it may justly be maintained that in his theory of transformation groups Lie has

himself created the most important of the newer departments of mathematics.

By the introduction of his concept of continuous groups of transformations he put the isolated integration theories of former mathematicians upon a common basis. The masterly reach of Lie's genius is illustrated by his encompassment of the fundamentally important theory of differential invariants associated with the English names Cayley, Cockle, Sylvester, Forsyth.

Thirteen years ago Sylvester announced his conception of 'Reciprocants,' a body of differential invariants not for a group, but for a mere interchange of variables. A number of Englishmen thereupon took up investigations about orthogonal, linear and projective groups, groups in whose transformations interchanges of variables occur as particular cases, and whose differential invariants are consequently classes of reciprocants, and of the analogues of reciprocants, when more variables than two are considered.

Now all these investigations were long subsequent to Lie's consideration of the groups in question as leading cases of a general conception. Thus they were merely secondary investigations!

Again, the theory of complex numbers appears as a part of the great 'Theorie der Transformationsgruppen.' Indeed, this continent of 'transformations' opened up and penetrated with such giant steps by Lie represents the most remarkable advance which mathematics in all its entirety has made in this latter part of the century.

Sophus Lie it was who made prominent the importance of the notion of group, and gave the present form to the theory of continuous groups. This idea, like a brilliant dye, has now so permeated the whole fabric of mathematics that Poincaré actually finds that in Euclid 'the idea of the group was potentially pre-existent,' and that he had 'some obscure instinct for it, without reaching a distinct notion of it.' Thus the last shall be first, and the first last.

In personal character Lie was our ideal of a genius, approachable, outspoken, unconventional, yet at times fierce, intractable. His work is cut short; his influence, his fame, will broaden, will tower from day to day.

George Bruce Halsted.

Austin, Texas.

SCIENTIFIC BOOKS.

Colour in Nature: A Study in Biology. By Marion J. Newbigin. London, John Murray. 1898. Pp. 344.

On page 300 of this work we read: "We have now completed our general survey of the colours and colouring-matters of organisms. * * * That the survey as a whole is halting and incomplete must be obvious to all. We have seen that it is as yet impossible to classify pigments in a logical manner; that most of the problems connected with the subject are entirely unsolved." These statements are indeed true; and yet the book is an interesting and valuable one, and will be of real assistance to the working biologist.

The whole subject of color in animals and plants has suffered from the fact that it concerns the chemist and physicist as well as the biologist, and in these days of intense specialization it is hard to find anyone competent to treat the matter in all its aspects. Dr. Newbigin has endeavored, with some success, to take all the more important facts into consideration; but it is practically impossible for any one individual to have that intimate acquaintance with the vital phenomena of every group of living organisms which is necessary for a satisfactory discussion of their coloration. It was Darwin's method to seek the assistance of numerous specialists in different branches, who supplied him with information which he brought together and interpreted in a masterly manner. It may be that Dr. Newbigin has not yet felt justified in asking for such help, but now that she has fairly won her spurs (if one may use such a phrase in regard to a lady) it is not unreasonable to hope that she will adopt the Darwinian system, and eventually provide us

with an account of animal and plant coloration which will cover the ground as completely as the knowledge of the day permits. In the meanwhile, we may be grateful to her for a work which will at any rate serve as an excellent introduction to the subject, and as more or less of a revelation to those whose studies have been confined to a limited field.

Attention is drawn to the interesting analogy between natural color-variations of organisms and the changes which can be induced in their pigments by suitable reagents. This is a matter which, though well known, has not received the attention it deserves, partly because those aware of the chemical reactions have not usually been familiar with the natural variations, and *vice versa*. It may be permissible, by way of illustration, to cite two new instances of this among the Coccidæ which have just come to the writer's notice. *Icerya rileyi* has a pure white ovisac, which is turned bright primrose yellow by chloroform, but regains its white color when the chloroform evaporates. A closely related form, *Icerya littoralis*, var. *mimosæ*, has the whole ovisac naturally of a delicate primrose yellow. The second case is more instructive. *Mytilaspis concolor* has ordinarily a white scale, but on February 5, 1899, Mr. P. J. Parrott discovered a variety (*M. concolor* var. *viridissima*, Ckll. and Parrott, ined.) in which the scales of both sexes are of a lively emerald green. This was on the campus of the Agricultural College, Mesilla Park, at the bases of stems of *Atriplex canescens*. The female insect itself, removed from beneath the scale, was found to be of a dark purple color, with a bright yellow patch in the anal region, and suffused crimson spots at intervals round the margins of the hind end. The purple color, when the insect was placed in caustic soda, *immediately became green*, but was changed back to purple by acetic acid. Now, it is evident in this case that the insect must have had an acid reaction, but the pigment transferred to the scale had apparently been turned green by the 'alkali' salts which are known to occur in the soil at Mesilla Park. This at once recalls the chætopterin pigments described by Dr. Newbigin on pp. 89–91 of her work, and it may be that we have a new member of that series.

On pp. 161–162 it is suggested that the resemblance between certain Heliconian butterflies and their Pierid mimics may be due, at least in part, to their relatively low organization and simple plan of coloration. In the Transactions of the Entomological Society of London, 1891, Mr. H. H. Druce published a paper on the Lycænid genus *Hypochrysops*, which inhabits Australia and the Malay Archipelago. To this paper are appended two beautiful colored plates, and the present writer was surprised to find that he could nearly match a number of very diverse species figured, as to color and pattern, among a series of Lycænidæ collected in Jamaica! The resemblance pertained only to the upper surface of the wings, the lower surfaces of the Jamaican insects being quite unlike *Hypochrysops*. Now the Lycænidæ show splendid 'optical' colors, and are certainly not simply organized as regards their coloration, so the suggestion made with regard to the Heliconians and Pierids would not hold. Neither, of course, is there any true mimicry, since the two sets of butterfiies occur on opposite sides of the world. Cases of this sort have been quoted as destructive to the theory of the utility of mimicry among insects, but to the writer they seem only to remove the difficulty which was felt in accounting for the origin of genuinely mimetic resemblances.

In a work of the kind now under review there must necessarily be details which could be adversely criticised. The writer had begun to take note of such, but it hardly seems worth while to dwell upon them. Botanists will undoubtedly complain that the space devoted to the colors of plants is much too short, and that several of the statements therein are too general or too sweeping. It will probably be thought by many readers that if Dr. Newbigin had made more or closer observations of living animals she would have had greater respect for natural selection. And, finally, some will wonder how it is that one who has enjoyed the beautifully pure colors of living creatures can have permitted her book to be bound in such a muddy and unpleasing blue.

T. D. A. COCKERELL.

MESILLA PARK, NEW MEXICO,
February 27, 1899.

The Dawn of Reason, or Mental Traits in the Lower Animals. By James Weir, M. D. New York, The Macmillan Co. Pp. xiii+234. Price, $1.25.

Dr. Weir has evidently been a close observer of animal life for many years, and his zeal has given him wider opportunities for useful observation than most amateurs and many professional naturalists have had. His book contains the more important of his own original observations of the intelligent activities of animals, some interesting verifications of the results gained by other observers, and his opinions about the nature of animal consciousness. Everything is purposely put in as simple language as possible, and this perhaps is a sufficient reason for the utter neglect of many observations, experiments and opinions which oppose his views. Lloyd Morgan, for instance, is nowhere mentioned, not even in the bibliography.

The popular nature of Dr. Weir's exposition prevents any discussion here of his observations on the morphology of the sense-organs of various animals, *e. g.*, jelly-fish, grasshoppers, beetles. He finds the marginal bodies of jelly-fish to be visual, not auditory organs, locates the auditory organs of grasshoppers in the anterior pair of legs, finds those of the Diptera to be the 'balanciers' of Bolles Lee, and those of the Cerambyx beetle to be in the maxillary palpi. It would certainly seem worth while for Dr. Weir to present his data in complete form soon, so that those competent may judge of the soundness of his conclusions. He gives no drawings.

One cannot help lamenting the mental attitude which served as the inspiration to Dr. Weir's observations of the intelligent activities of animals. He craves a high development of mentality for the animals and has his eyes open only to possible evidence of it. He likes to find keen senses better than dull ones, reasonings than instincts, knowledge than ignorance. He psychologizes about animals as a lover might psychologize about his beloved. The disadvantages are obvious. On the other hand, there are some advantages, at least in the enthusiasm and patient labor which perhaps are due to the eulogizing temper. Anyone interested in the progress of comparative psychology must wish well to a man who, without the incentives of the professed naturalist, makes it a labor of love to watch animal life. I, for one, shall welcome such observations, even though they are more one-sided than Dr. Weir's. His favoritism toward animals, though it has deprived us of any records of unintelligent conduct and perhaps prevented the repetition of some tests and even distorted facts, has still failed to injure a very considerable number of suggestive and important observations. It will pay any student of animal psychology to read the book for the sake of these. They furnish interesting, and we hope reliable, data about the adaptive reactions of micro-organisms, the formation by insects of new associations in response to new situations, the formation by reptiles of habits due to the association of novel sights and sounds with certain reactions, about 'play' among insects, strange 'friendships' between animals, letisimulation, the activities of the harvesting ants, etc. A sample of Dr. Weir's keenness is his theory that the continual barking of dogs at night is explainable by the supposition that they bark at an echo. This hypothesis he supports by some very striking facts.

Of Dr. Weir's opinions about the meaning of his facts there is little to be said. His mind does not move freely and surely among psychological terms or theories or deductions. Reason means for him the source of all performances above the level of instinct, and his only basis of discrimination is the difference between high and low. His only theoretical problem is as to whether or not the human mind has developed from the brute mind. It will be a birthday for animal psychology when naturalists realize that this is among the least of its problems.

Edward Thorndike.
Western Reserve University.

SCIENTIFIC JOURNALS AND ARTICLES.

The December number of the *Bulletin of the American Mathematical Society* contains an account of the October meeting of the Society, by the Secretary, Professor F. N. Cole; 'Concerning a Linear Homogeneus Group in $C_{m,q}$ Variables Isomorphic to the General Linear

Homogeneous Group in m Variables,' by Dr. L. E. Dickson; 'A Second Locus Connected with a System of Coaxial Circles,' by Professor Thomas F. Holgate; 'Reciprocal Transformations of Projective Coordinates and the Theorem of Ceva and Menelaos,' by Professor Arnold Emch; 'Notes'; 'New Publications.' The January number of the *Bulletin* contains a report on the 'Theory of Projective Invariants: The Chief Contributions of a Decade,' by Professor H. S. White; 'Reye's Geometrie der Lage,' by Professor Charlotte Angas Scott; 'Burkhardt's Theory of Functions,' by Professor Maxime Bôcher; 'Darboux's Orthogonal Systems,' by Professor Edgar Odell Lovett; 'The New Mathematical Encyclopædia,' by Professor James Pierpont; 'Errata'; 'Notes'; 'New Publications.' The February number of the *Bulletin* contains an account of the Fifth Annual Meeting of the Society, by the Secretary; 'The December Meeting of the Chicago Section of the Society,' by Professor Thomas F. Holgate; 'Report on Recent Progress in the Theory of Groups of a Finite Order,' by Dr. G. A. Miller; 'Note on Burnside's Theory of Groups,' by Dr. G. A. Miller; 'On a Regular Configuration of Ten Line Pairs Conjugate as to a Quadric,' by Professor F. Morley; 'Shorter Notices,' by Professors Ernest W. Brown, Edgar Odell Lovett, J. W. A. Young, Alexander Ziwet; 'Notes'; 'New Publications.'

American Chemical Journal, March: 'On the Rearrangement of Imido-Esters,' by H. L. Wheeler and T. B. Johnson. 'On an Isomer of Potassium Ferricyanide,' by J. Locke and G. H. Edwards. By treating potassium ferricyanide with potassium chlorate and hydrochloric acid an isomer of this salt was obtained. An isomeric silver salt was also prepared and the reactions studied. In some cases the reactions of the isomers are so different that the author does not hesitate to accept this substance, which he calls potassium β-ferricyanide, as a new form. 'Reaction of Orthodiazobenzoic Acid with Sulphurous Acid and Copper Powder,' by W. E. Henderson. Experiments were carried out to test the statements so generally found in text-books that sulphonic acids are formed from the decomposition of diazo compounds by sulphurous acid in the presence of copper powder. The results showed that, under ordinary conditions, sulphonic acids were not formed. 'Direct Nitration of the Paraffins,' by O. A. Worstall. The author finds that the results as given in his earlier paper on the action of nitric acid on the paraffins hold for all the paraffins studied. 'Higher Primary Nitroparaffins,' by R. A. Worstall. The author has continued the study of the derivatives of the higher paraffins on the line suggested by Victor Meyer in his study of the lower members of the series. 'The Action of Ethylic Oxalate on Camphor,' by J. B. and A. Tingle. 'Liquid Acetylene Diiodide,' by E. H. Keiser. A second form of the three theoretically possible ones has been obtained in liquid form. 'A Simple Color Reaction for Methyl Alcohol,' by S. P. Mulliken and H. Scudder. The alcohol is converted into formic aldelyde by plunging a hot copper wire into it. Resorcin and sulphuric acid are then added and a characteristic color reaction follows. 'Reactions for the Detection of the Nitrogroup,' by S. P. Mulliken and E. R. Barker. The first method depends on the reduction to hydroxylamine and the test for this with silver nitrate, and the second on the conversion into rosaniline.

J. ELLIOTT GILPIN.

THE *Osprey*, for January, has for its first article some interesting 'Notes on *Eugenes fulgens*' by F. C. Willard, accompanied by a fine plate showing four nests. Next comes descriptions of the 'Nesting of the Alaska Bald Eagle,' by George G. Cantwell, followed by descriptions of the habits in captivity of Great Horned Owls, Barn Owls and young Short-eared Owls respectively, by M. A. Carriker, D. A. Cohen and Ludwig Kumlien. 'A Visit to Pelican Island, Indian River, Florida,' is described by L. W. Brownall, and the 'Nesting of the Black-and-White Warbler,' by J. Warren Jacobs. Other brief articles, editorials, notes and reviews complete the number.

THE leading article of the *Journal of the Boston Society of Medical Sciences* is a series of 'Observations upon the Elastic Tissue of Certain Human Arteries,' by George B. Magrath. Richard M. Pearce has a paper on 'Scarlet Fever; its Bacteriology, Gross and Minute

Anatomy,' and Horace D. Arnold one on the 'Weight of the (Normal) Heart in Adults,' the conclusion being that the average weight for males is 290 grams and for females 260 grams. The final article, 'A Study of the Encapsulated Bacilli,' by Lawrence W. Strong, finds that the gas production of these bacilli affords a valuable aid for their study and identification.

THE *Electrical World* and the *Electrical Engineer* will be issued, hereafter, as one publication, to be known as the *Electrical World and Engineer*, under the editorship of T. Commerford Martin and W. D. Weaver. W. J. Johnston, former editor of the *Electrical World*, has retired.

DR. W. P. WYNNE, F. R. S., has been elected editor of the Journal of the British Chemical Society.

SOCIETIES AND ACADEMIES.

THE ANNUAL MEETING OF THE NEW YORK ACADEMY OF SCIENCES, FEBRUARY 27, 1899.

AFTER the reading of the minutes of the last annual meeting, the reports of the officers for the year just closed were called for by the President, Professor Henry F. Osborn.

The Corresponding Secretary reported briefly that he had succeeded in correcting and revising the list of honorary and corresponding members, after a considerable amount of correspondence, and that the corrected list would be published in Part I. of the volume of Annals for 1899. The Recording Secretary then presented the following report, summarizing the progress and work of the Academy during the preceding year:

The last year of the Academy has been extremely satisfactory, and its affairs are in a much more promising condition than heretofore. Interest in our meetings has increased during the year, and the number of people cooperating in our work is much larger than ever before.

During the last fiscal year there have been thirty-one meetings of the several sections, three public lectures and one public reception. The sections now organized are those of Astronomy and Physics, Biology, Geology and Mineralogy, and of Anthropology, Psychology and Philology. The latter section has been divided into two sub-sections, for economy of effort. Particular mention should be made of the good work and increased interest in the sub-section of Anthropology and Psychology, largely due to the personal and persistent efforts of Dr. Boas.

During the year a total of ninety-four papers has been presented before the Academy, thirty-seven new members have been elected, twelve have resigned, leaving a total of three hundred and thirty-five on the Secretary's list, including six new life members. The Fifth Annual Reception held in April last was in some ways the most successful in the history of the Academy. During the year the by-laws have been very completely revised, simplified and made workable, particularly in such a way as to give the individual sections and sectional officers more importance in the program, and so as to reduce the number of business meetings at which the Academy must be formally organized for general business to one each month. The public lectures have been more firmly established than heretofore, and have been assigned to the various sections so that each department may be popularly represented. The printed program of the year's meetings has been announced in advance, and has been found very helpful.

The publications of the Academy have been greatly improved as to quality, appearance and dignity, by the change incorporated in January last, when the Transactions were abolished. The thanks of the Academy are certainly due to our enthusiastic and very careful editor, Mr. van Ingen, for the great amount of work and care that he has put upon the publications. It is through the publications only that we are known abroad in the world, and it is very necessary that we should thus appear in the most favorable manner possible.

The Academy is in great need of more money for publication, and our efforts should be devoted as fully as possible to the securing of contributions for such work. We are continually obliged to decline valuable scientific papers by our members because of a lack of funds for printing. This is a condition of affairs which should not be allowed to continue long.

It is a great pleasure to the Academy to feel that certain of the scientific wants of the city are soon to be met, owing to the encouragement given by one of our Patrons, who has always been interested in the Academy. I refer particularly to the gift to the Scientific Alliance, of which the New York Academy of Sciences is the original member, of $10,000 for a scientific building, donated by Mrs. Herrman. During the coming year it is hoped to bring the several sections in touch, so as to have a uniform policy of procedure, and the manner of printing the proceedings will be simplified and unified.

The report of the Treasurer showed the finances to be in a promising condition, but that the expenses too nearly equalled the income, and that endowments are very necessary if the work is to be increased as it should be.

One of the most interesting features of the meeting was the report by the Editor of the Annals concerning the details of his work during the last year in printing the volume just finished according to the new plan as to typography, pagination, illustration and general form, which was adopted a year ago and which has proved extremely successful and gratifying.

The last official report was a brief one by the retiring Librarian concerning the present condition of the library, which is now housed in a large room in Schermerhorn Hall, of Columbia University, and available for reference by all working scientists and members of the Academy.

The following list of honorary and corresponding members was then elected, and seventeen resident members were made Fellows because of their attainments in scientific work:

HONORARY MEMBERS.

Lord Rayleigh, M.A., D.C.L., LL.D., F.R.S., Royal Institution of Great Britain, Albemarle St., Piccadilly, N. W., London.

George Howard Darwin, M.A., F.R.S., Trinity College, Cambridge, Eng.

CORRESPONDING MEMBERS.

Dr. Louis Dollo, Musée d'Histoire Naturelle, Brussels, Belgium.

Dr. Otto Jaekel, Kgl. Museum für Naturkunde, Invalidenstr. 43, Berlin.

Professor Dr. Eberhard Fraas, Kgl. Naturalien Kabinet, Stuttgart, Germany.

Professor Dr. Charles Depéret, Faculté des Sciences, Lyons, France.

Dr. C. W. Andrews, British Museum of Natural History, London, England.

Dr. Max Schlosser, Palaeontologische Sammlung des Staates, Alte Akademie, Munich, Germany.

G. H. Boulenger, British Museum, London, England.

Professor G. B. Howe, Normal College of Science, S. Kensington, London, England.

Dr. Walter Innes, School of Medicine, Cairo, Egypt.

Dr. A. Liversidge, Sydney, New South Wales.

Professor Mansfield Merriman, Lehigh University, South Bethlehem, Pa.

Dr. Stuart Weller, University of Chicago, Chicago, Ill.

Professor Ludwig Boltzmann, University of Vienna, Vienna, Austria.

Professor P. LaCroix, Musée d'Histoire Naturelle, Paris, France.

Dr. A. Smith Woodward, British Museum of Natural History, London.

Professor Dr. Fried. Kohlrausch, Physikalish Technische Reichsanstalt, Charlottenberg, Marshstrasse 25, Berlin.

Professor R. H. Traquair, Museum of Science and Art, Edinburgh, Scotland.

Professor W. C. Brögger, Christiania, Norway.

J. G. Baker, Royal Gardens, Kew.

Professor Wilhelm Ostwald, University of Leipzig, Leipzig, Germany.

The list of officers given below was then elected by ballot:

President, Henry F. Osborn.

1st Vice-President, James F. Kemp.

2d Vice-President, Chas. L. Bristol.

Corresponding Secretary, William Stratford.

Recording Secretary, Richard E. Dodge.

Treasurer, Charles F. Cox.

Librarian, Bashford Dean.

Councillors, Franz Boas, Charles A. Doremus, William Hallock, Harold Jacoby, Lawrence A. McLouth, L. M. Underwood.

Curators, Harrison G. Dyar, Alexis A. Julien, George F. Kunz, Louis H. Laudy, William D. Schoonmaker.

Finance Committee, Henry Dudley, John H. Hinton, Cornelius Van Brunt.

The formal work of the evening was followed by the annual address of the President. Professor Osborn took for his title 'The Succession of Mammalian Fauna in America, compared with that in Europe during the Tertiary Period.'

The formal meeting was followed by refreshments and a social gathering, which lasted until a relatively late hour.

RICHARD E. DODGE,
Recording Secretary.

THE PHILOSOPHICAL SOCIETY OF WASHINGTON.

THE 497th meeting of the Society was held on March 4th, at 8 p. m., in the assembly room of the Cosmos Club. The first paper was by Professor F. H. Bigelow on 'The Influence of Electricity on Vegetation.' It was stated that vegetation under the Aurora belt shows remarkable developments, due not to the length of the summer day, but to the electric currents. Experiments indicate that static electricity, supplied by machines, when applied to plants increases their growth about 40 per cent. Extensive trials in many places and under different conditions generally confirmed this result.

The second paper was by Surgeon-General Sternberg on 'Some Sanitary Lessons of the Late War.' An abstract of this very interesting and instructive address has not yet come to hand.

E. D. PRESTON,
Secretary.

GEOLOGICAL SOCIETY OF WASHINGTON.

AT the 89th meeting of this Society, held in Washington, D.C., on March 8, 1899, Mr. Arnold Hague, U. S. Geological Survey, exhibited a geological relief map of the Yellowstone Park and of the Absaroka Range, in northwestern Wyoming, showing some of the physical features of the latter region by means of lantern illustrations. The map is constructed on the scale of one mile to an inch, the area represented being approximately 75 miles square. The base of the model is taken at 5,000 feet above sea level, from which rise several dominating peaks showing elevations of over 12,000 feet above sea level. It requires about forty distinct colors to represent the different geological formations into which the sedimentary and igneous rocks have been divided. All the geysers and hot springs areas are delineated, together with the regions of extinct hydro-thermal action. In the model a sharp contrast between the rhyolite plateau of Yellowstone Park of Pliocene age and that of the eroded and dissected plateau of the Absarokas of Miocene age is clearly brought out. Mr. Hague stated that he hoped the map would be sent to the Paris Exposition next year. The lantern slides were selected to illustrate the manner in which the Absarokas were built up by the gradual accumulation of breccias, agglomerates and basalt flows, forced upwards from numerous fissures and vents during a long period of time, and the elevation of the range by the intrusion of powerful stocks of gabbro, syenite, diorite, diorite-porphyry and granite-porphyry. The character of the different breccias, the incisive trenching of the deep canyons, and the stocks, together with their associated sheets and network of dikes, were discussed.

Mr. F. B. Weeks, U. S. Geological Survey, gave some observations made last summer in the course of a reconnaissance in Jackson Basin, northwest Wyoming.

The Jackson Basin, he said, occupies a depression within the Rocky Mountains, of Wyoming, of 5 to 8 miles in width and 45 miles in length. The Teton range forms a lofty, precipitous barrier along its western side. The valley has an elevation of 6,200 to 6,800 feet, and the Tetons rise 7,000 feet above it. The Tetons are noted for their wonderful Alpine scenery. Jackson Lake and several smaller lakes occur within the valley—all of glacial origin. The northeastern portion of the basin is covered with numerous morainal ridges and hillocks. The eastern side is buried beneath a great mass of material brought down by glacial streams. They have the forms of huge deltas, spreading out from the foothills in fan-shaped areas, several miles long and as many miles in width where they reach the Snake River. Along some of the main streams terracing has been well developed. The streams flowing over these deltas follow well defined courses, but have a tendency to spread laterally instead of widening and deepening their beds. The Upper and Lower Gros Ventre buttes are prominent outliers of the Gros Ventre range. They are formed, in large part, of Paleozoic rocks, and are probably directly connected with the main range. The heavy mantle of débris makes it impossible to trace a definite connection.

The meeting closed with some remarks by Mr. W. Lindgren, U. S. Geological Survey, on the Boise Folio (No. 45, of the Geol. Surv.), recently published.

WM. F. MORSELL.

DISCUSSION AND CORRESPONDENCE.

ON THE MAKING OF SOLUTIONS.

TO THE EDITOR OF SCIENCE: A remark in a recent paper by Professor Macloskie calls my attention afresh to a curious error which, so far as I know, is universally current in our zoological laboratories. Professor Macloskie remarks (SCIENCE, Vol. IX., p. 206) "a 1% solution of cane sugar in water, * * * that is 342 grams, * * * dissolved in 34,200 grams of water." In other words, a 1% solution is made by mixing 1 part of the substance to be dissolved with 100 parts of the solvent. In this conception the zoologists appear to be at one. It is sufficient to refer to any of the well-known text-books: Marshall and Hurst, 'Practical Zoology,' 4th ed., p. 464; Gage, 'The Microscope,' 6th ed., p. 179; Dodge, 'Elementary Practical Biology,' p. 391. Like many other text-books, Huxley and Martin's 'Practical Biology' (revised ed., p. 496), does not directly commit itself to the error, but gives directions to make the 'normal saline solution' by mixing 7.5 grams of salt with a liter of water. That the normal saline solution is a ¾% solution is directly stated by Whitman ('Methods of Research,' etc., edition of 1885, p. 207), and Lee (The Microtomist's Vade-mecum, 4th ed., p. 263.),

These citations abundantly prove that Professor Macloskie's conception of a 1% solution corresponds with that of other zoologists. If, however, we ask a chemist how such a solution is made, the reply will be: "Dissolve one part of salt, sugar, or whatever the substance may be, in *ninety-nine* parts of the solvent." And that this is logically correct becomes self-evident upon a moment's thought. A 1% solution of HCl, as all will agree, consists of one part of the acid to ninety-nine parts of water. Why should the fact that in one case we deal with a solid, in the other with a liquid, alter the case?

It would seem that unless, or until the zoologists come into agreement with the chemists, every investigator in publishing his researches should make a point of preventing ambiguity by stating whether his 1%, 5%, 20% solutions of solids are compounded on the logical or the zoological plan.

M. A. WILLCOX.

WELLESLEY COLLEGE, March 6, 1899.

THE ORIGIN OF NIGHTMARE.

OVER and over again when a child I was for years the victim at night of a certain form of mild nightmare, so that it came to be to my fearful imagination no insignificant part of my unpleasant experiences. This nightmare always took the form of a great wave of something gradually rolling towards me and finally engulfing and oppressing me to a painful extent. It would roll up a huge shapeless mass of no particular material, but always irresistibly towards me helpless and overwhelmed. Most often it finally appeared to be a huge soft pillow or even formless feather bed, but without color or other qualities save that of engulfing and terrifying. At its worst on various occasions this mass as it rolled up became a huge fat boar, defined as such, however, only subconsciously, but always dreadful in its power to overwhelm me. All this was years ago.

One night recently, as I was falling asleep in bed in a lighted room, I became gradually aware of that sensation which compression of a nerve produces, a vague and quite indefinite sense of discomfort localized only in the region about my head and arms, but in my state of somnolence only a growing sensation of discomfort pressing on my consciousness. Increasing steadily, it finally began to awaken me, and I then became distinctly conscious of the well-remembered nightmare of my childhood beginning to approach. With the noise in the room I was now sufficiently awake to be interested in this familiar visitor, and I lay still deliberately. Gradually the mass rolled up towards me exactly as of yore, with no terror in its coming now, until finally it was upon me and all about me oppressively. I very slightly moved my arm (upon which my head was lying), and the nightmare was for the moment lost sight of in the sensations now localized there. I opened my eyes and instantly the whole experience vanished, closed them and it instantly returned

in all its force and peculiarities. Over and over again this little experiment was performed without variation in its results, until, finally, satisfied, I moved my head off my arm and stretched my arm out of its cramped position, and felt no more this *bête noir* of earlier days, now again returned, bringing with it emphatic and unmistakable explanation of its cause.

G. V. D.

ASTRONOMICAL NOTES.

A NEW SATELLITE OF SATURN.

A NEW satellite of the planet Saturn has been discovered by Professor William H. Pickering at the Harvard College Observatory. This satellite is three and a half times as distant from Saturn as Iapetus, the outermost satellite hitherto known. The period is about seventeen months, and the magnitude fifteen and a half. The satellite appears upon four plates taken at the Arequipa Station with the Bruce Photographic Telescope. The last discovery among the satellites of Saturn was made half a century ago, in September, 1848, by Professor George P. Bond, at that time Director of the Harvard College Observatory.

EDWARD C. PICKERING.
HARVARD COLLEGE OBSERVATORY,
CAMBRIDGE, MASS., March 17, 1899.

NOTES ON PHYSICS.

THE NERNST LAMP.

THE electric lamp recently invented by Nernst, as has been stated in this JOURNAL, consists of a small rod of magnesia which is heated to brilliant incandescence by an electric current which is pushed through it by an electromotive force of several hundreds of volts. The rod must be heated nearly to a red heat by a blowpipe or other independent means before it passes sufficient current to operate.

A number of these lamps have been made in the Physical Laboratory at Bethlehem, Pa. It has been found that a rod of pure magnesia can scarcely be started even with 1,000 volts and a good blow pipe. The surrounding air becomes electrically too weak to withstand the high electromotive force at a temperature lower than that required to make the rod a sufficiently good conductor. This is true even when the rod has been heated to softness beforehand in a temporary mounting.

The conductivity of the rod may be completely controlled by mixing with the magnesia varying amounts of silica and of fusible silicates. A satisfactory lamp is made as follows: Pure calcined magnesia (heavy) is thoroughly mixed with two or three per cent. of powdered silica, one or two per cent. of magnesium sulphate, and one per cent. or less of sodium or potassium silicate (water glass). The mixture is dried until it is just moist enough to pack under pressure. A small piece of brass tubing is lined with a roll of several thicknesses of stiff writing paper, and the mixture is tamped into this tube. The tube is then baked until the paper is burned, when the rod of magnesia may be removed. This rod is then laid upon a bed of magnesia (powdered lime would, perhaps, answer) and by means of carbon terminals an alternating current is passed through the rod, heating it first to redness by a blow pipe. With some care a very hard and compact rod of magnesia is thus formed which is then ground to a thin rod with large grooved ends. Platinum wire is wound on these grooved ends and, if desired, cement made of water glass and powdered magnesia may be used to cover the platinum. The two platinum wire terminals may then be bound to the sides of a small glass tube as a support. A lamp made in this way may be started easily, although its resistance rises slowly with continued use, owing, perhaps, to the volatilization of the potassium or sodium silicate. Calcium silicate would, perhaps, be more satisfactory in this respect.

A very striking experiment may be performed with a piece of glass tubing several inches long wound with copper terminals at its ends. The tube begins to pass considerable current at a low red heat, with a few hundreds of volts, and is quickly melted by the current. A thin-walled tube half an inch or more in diameter is best, and it should be heated along one side only so that the cool portion of the tube may for a short time serve as a support for the hot conductive portion.

W. S. F.

PYROELECTRICITY AND PIEZOELECTRICITY.

W. VOIGT (*Wiedemann's Annalen*, No. 13, 1898) shows that the electrification of certain crystals by heating (pyroelectricity) and the electrification by deformation (piëzoelectricity) are in general one and the same phenomenon, and that it is only in such a crystal as tourmalin, which has a single axis distinguished from all other axes by characteristic physical properties, that pyroelectricity is not due wholly to the deformation accompanying a rise of temperature. Professor Voigt also points out that a plate of tourmalin can be used to generate accurately known electric charges by subjecting it to measured compression, and he gives the results of a determination of an electrostatic capacity based upon the known charge generated by a tourmalin plate and the known e. m. f. of a standard cell. W. S. F.

THE ROTARY CONVERTER.

IN two short articles in the *Electrical World*, for December 17th and 24th, Mr. C. P. Steinmetz gives a quite complete discussion of the theory and action of the rotary converter, a machine used to convert alternating current into direct current, mainly in connection with long distance transmission. Mr. Steinmetz's papers are, almost without exception, very difficult to read for the reason, chiefly, that he always gives a great deal of precise information about difficult subjects not generally understood. The present paper cannot, of course, be abstracted, but it is mentioned for the reason that Mr. Steinmetz deserves to be more generally known as one of the foremost electricians of our time; that he is a scientific electrician is a matter of course.

W. S. F.

THE TELESCOPE-MIRROR-SCALE METHOD.*

PROFESSOR S. W. HOLMAN has given in the *Technology Quarterly*, for September, 1898, a most complete and usable discussion of the telescope-mirror-scale method for measuring angular deflections. Almost at the very beginning of the paper a list of the fourteen instrumental errors is given, together with directions for making the adjustments which are necessary to reduce each error to a prescribed value. Following this is a general discussion of each error of adjustment and a derivation of the error in angle due to each. Most physicists have, of course, looked into the detailed theory of the telescope-mirror-scale method in spite of the fact that the literature on the subject is not generally accessible, but the habitual use of the method for rough measurements makes one lose sight of a dozen or more of the adjustments and precautions which are necessary in accurate work, and, therefore, almost every physicist will find this pamphlet of Professor Holman's a useful reminder when the need arises to use the method with all the precision it is capable of. W. S. F.

*Published separately by John Wiley & Sons, New York. Price, 75 cents.

NOTES ON INORGANIC CHEMISTRY.

SOME time ago a committee was appointed by the German Chemical Society to formulate an atomic-weight table which should serve as a basis for practical use in analytical calculations. This committee consisted of Professors Landolt, Ostwald and Seubert, and has recently brought in a report which has been widely published. With three exceptions, the decimals in the atomic weights are given only as far as the last figure is practically correct. The weights as far as given agree in general with those published by Professer F. W. Clarke. The most interesting point in connection with the table is that the basis used is the atomic weight of oxygen = 16. It is now a number of years since Dr. F. P. Venable and others in this country and abroad uttered strong protests against the use of hydrogen = 1 as a standard, especially since the atomic weights with few exceptions are determined with reference to oxygen, and at that time the ratio between hydrogen and oxygen was uncertain. Now that this ratio has been, thanks to Professor Morley, rendered almost certain to three decimal places, it is still unnecessary and unscientific to bring in even this little uncertainty, which in the elements of high atomic weight amounts to quite an appreciable quantity. Professor Seubert has been one of the strongest advocates of the basis H = 1, and it is noteworthy that he has agreed to the committee report. In the report Seubert says that, while H = 1 is in

principle the most correct and natural, he agrees to the report chiefly because with O = 16 many of the weights most frequently used in calculations are represented by whole numbers, and hence these numbers are most conveniently used. Landolt adds that he hopes this report will lead to an international agreement as to the figures used.

In a recent paper in the *Journal für praktische Chemie*, W. Eidmann describes the action of metallic magnesium upon compounds containing nitrogen, especially upon the cyanids. At a red heat almost all compounds, inorganic and organic, which contain nitrogen are decomposed, generally with the formation of magnesium nitrid, Mg_3N_2. The cyanids of the alkalies and alkaline earths are decomposed without explosion, the carbid of the metal being formed. This, Eidmann says, shows that the ordinarily accepted formula of the cyanids, *e. g.*, $Ba\begin{matrix} C \equiv N \\ C \equiv N \end{matrix}$ is correct. In the case of those cyanids which decompose at a red heat, as those of zinc, nickel, lead, copper, etc., the reaction with magnesium is more violent and decomposition into magnesium nitrid, carbon and the metal ensues. In the case of those cyanids, as those of silver and mercury, which decompose below a red heat the liberated cyanogen reacts with magnesium with explosive violence.

A series of analyses of waters from wells near the sea-shore are published by P. Guichard in the *Bulletin Société Chimique*. The water in these wells rises and falls with the tide, while the composition of the water leads to the conclusion that there is no direct connection between the wells and the sea, and, hence, it follows, according to the author, that subterranean waters must be affected by the moon, even as the ocean. This conclusion will, doubtless, find many to dissent from it.

A description is given in the *Pharmaceutische Zeitung* by Alfred Zucker of the manufacture of whitelead by electrolysis, at Dellbrück, according to the Luckow process. The electrolyte is a 1½% solution of 80% sodium chlorid and 20% sodium carbonate. The anode is soft lead, the kathode hard lead. The current is 0.5 ampère per square centimeter at 2 volts. Water and carbon dioxid are carefully added as the electrolysis proceeds. With care as to the strength of the electrolyte, a purity of whitelead is obtained not hitherto reached. The hygienic regulations of the factory are worthy of mention. Every operative receives daily one liter of fresh milk, and at the conclusion of his daily work must clean very thoroughly his hands, finger nails, etc. In addition he receives Glauber's salts, and every fortnight must take a complete warm bath in water which contains a certain amount of liver of sulfur. By these precautions all cases of saturnine poisoning have been avoided for several years.

Although not under the head of inorganic chemistry, mention may be permitted of a description of the manufacture of artificial silk in a recent number of the *Zeitschrift für Angewandte Chemie* from the pen of H. Wyss-Naef. The first practical use of the process was in 1889. The raw material is carded cotton which is first converted into nitrocellulose by a bath of strong nitric and sulfuric acids. After washing and drying it is dissolved in a mixture of alcohol and ether. This collodion is then spun through openings .08 mm. diameter. The alcohol and ether evaporate almost instantly on spinning and the material is carefully dried. It is then treated by a secret process to reduce the nitro groups, ammonium sulfid being probably the reducing agent used. The silk is then bleached with chlorin and is ready for the market.

J. L. H.

CURRENT NOTES ON METEOROLOGY.

THE THEORY OF CYCLONES AND ANTICYCLONES.

A publication of unusual interest, containing conclusions of the greatest importance in meteorology, has been issued as *Bulletin* No. 1 (1899), of the Blue Hill Meteorological Observatory ('Studies of Cyclonic and Anticyclonic Phenomena with Kites,' by H. Helm Clayton). This is a study of the results obtained during the kite flights of September 21st–24th and of November 24th–25th last, and it will aid materially towards once more strengthening belief in the older Ferrel, or *convectional* theory of cyclones and anticyclones, as opposed to the newer Hann, or *driven* theory. Lack of space

prevents mention of many of the striking facts set forth in this *Bulletin*. The flights of September 21st–24th brought down records from altitudes of 2,000 to 3,400 meters, in a well-marked anticyclone, and in a succeeding cyclone which followed the same track. The temperature near the center of the anticyclone was the same at 2,100 meters as at 1,200 meters, and the humidity at the greater altitudes was excessively low. These results agree with those previously found in similar conditions. The axis of the anticyclone was inclined backwards, the high pressure occurring later at high than at low levels. Up to 3,000 meters the temperature of the air was higher on the day of the cyclone than on the day of the anticyclone—a normal condition at Blue Hill, as previous kite ascents have shown. A further notable discovery is that cyclonic and anticyclonic circulations observed at the earth's surface in this latitude do not seem to embrace any air movement at greater altitudes than 2,000 meters, except in front of cyclones. Above 2,000 meters there seem to be other poorly developed cyclones and anticyclones, with their centers at entirely different places from those on the earth's surface, and with different wind circulations.

On November 24th–25th the kite meteorograph was sent up near the center of a cyclone and in a succeeding anticyclone. From sea-level to 2,300 meters the temperature was 13°–24° F. higher on the day of the cyclone (November 24th) than on the following day. The results of the observations on November 24th–25th also go to show that when the cold in the rear of a surface cyclone is exceptionally severe, the axis of the cyclone is inclined backward so sharply that the circulation breaks into two or more systems. Thus there come to exist a surface cyclone, a mid-air cyclone and an upper-air cyclone. On November 25th, at 3,000 meters, there existed a cold-center cyclone, in which the air had a descending component of motion, as indicated by the low humidity.

The results of the careful study made by Mr. Clayton lead him to the view that the *convectional* theory of cyclones is the true one. This *Bulletin* again bears evidence to the admirable work which is being done by the staff of the Blue Hill Observatory, and to the important contributions which Mr. Clayton and his assistants, with Mr. Rotch's liberal support, have made to meteorology.

CARBONIC ACID IN DEATH GULCH.

THE amount of carbonic acid in the atmosphere, which, under ordinary conditions, averages about 0.03%, may, in exceptional circumstances, attain a considerably higher percentage. In certain volcanic districts the amount of carbonic acid may be large enough to cause the death of animals which stray into the hollows where, owing to its density, the gas collects. The Grotto del Cane, near Naples, is a region of this sort. Another is Death Gulch, in the Yellowstone National Park. In an account of a recent trip in the Park, in *Appleton's Popular Science Monthly* for February, Jaggar reports his discovery, in Death Gulch, of the carcasses of eight bears, all of which had doubtless been asphyxiated by the excessive amount of carbonic acid in the air.

R. DEC. WARD.

HARVARD UNIVERSITY.

ZOOLOGICAL NOTES.

NEOMYLODON LISTAI.

DR. EINAR LÖNNBERG describes at length* some portions of skin found in a cave at Eberhardt, near Last Hope Inlet, 51° 35′ S., 72° 38′ W., in the Territorio de Magallanes, Chile, and obtained by the Swedish expedition which visited Tierra del Fuego in 1896. The cave, located a few kilometers from the coast and about 500 feet above sea-level, was about 600 feet deep and 150 feet wide at the entrance. It was discovered by some farm laborers, who promptly destroyed the human skeletons found in the cave, although they fortunately preserved some pieces of thick, strange-looking skin, and the sheath of a claw found partly imbedded in the stalagmitic deposit of the floor. The claw and two pieces of skin were secured by Nordenskjold; the smaller piece measured about 7 × 15 cm.; the larger, irregular in shape, 50 × 76 cm., is believed to be from the left fore leg. The small

* Reprint from *Wissenschaftl. Ergebnisse Schwedischen Expedition nach den Magellansländern unter leitung von Otto Nordenskjold.*

fragment of skin is 1 cm. thick covered, externally with coarse, dirty yellowish hair, and internally so thickly set with rounded ossicles as to suggest a cobblestone pavement. The inner surface of the larger piece does not show any ossicles, but in the freshly-cut margin they are apparent, although small and completely imbedded in the skin; the hair on this fragment is from 5 to 9 cm. long. Under the microscope a transverse section of this hair is seen to be solid, lacking the central pith usually present, and on comparison with the hairs of various South American edentates its greatest likeness is found in the central axis of the hair of *Bradypus*. The microscopical structure of the ossicles, which is described at length by Dr. Lönnberg, is strikingly like that of the ossicles of the true fossil *Mylodon*. The claw, 104 mm. long by 34 wide, is considered to belong to *Neomylodon*, as there is no existing South American mammal provided with similar claws, and is believed to have belonged on a hind foot. The animal is estimated to have been *at least* 6 feet long and 4 feet or so high at the shoulder. After a careful consideration Dr. Lönnberg comes to the conclusion that, while *Neomylodon* was contemporaneous with early man and was used as food, it certainly does not exist at present, because it is absolutely impossible for it to have eluded the sharp eyes of the native Indians; neither is it identical with the animal that Ramon Listai is said to have shot at. It will be noted that the conditions under which the skin was preserved are very similar to those which led to the preservation of portions of the skin and feathers of *Dinornis*.

F. A. L.

SCIENTIFIC NOTES AND NEWS.

The Second International Conference on a Catalogue of Scientific Literature requested the delegates from the countries represented to take steps for the formation of committees to study the various questions relating to the Catalogue, and for the United States the following committee has been named: Dr. J. S. Billings, Professor Simon Newcomb, Dr. Theodore N. Gill, Professor H. P. Bowditch, Dr. Robert Fletcher, Mr. Clement W. Andrews and Dr. Cyrus Adler. Different universities and scientific societies have been invited to form committees to report upon the questions involved.

The appointment of Mr. Herbert Putnam as Librarian of the National Library will be welcomed by all friends of science and learning. It is well known that Mr. Putnam has excellently administered the Public Library of Minneapolis and the Boston Public Library, and will undoubtedly make the National Library what he has himself said it should be, "the foremost library in the United States, a national library, the largest in the United States, a model and example of assisting the work of scholarship in the United States." Men of science are directly interested in this appointment, as the great collection of scientific books of the Smithsonian Institution is deposited in the Library.

Dr. Thomas J. See, recently appointed professor of mathematics in the Naval Observatory, has been designated as Chief of the Nautical Almanac.

Professor Patrick Geddes, of Edinburgh, is at present visiting the United States with a view to sociological and other studies. Professor Geddes is well known for his accomplishments and versatility in biological science and for his efforts to improve sociological conditions in Edinburgh.

Mr. G. F. Stout, recently appointed Wilde lecturer on mental philosophy at Oxford, and Mr. Charles Stewart, Curator of the Museum of the Royal College of Surgeons, London, have been given the degree of LL.D. by the University of Aberdeen.

The Stockholm Society for Geology and Geography has awarded its Vega medal to Professor Georg Schweinfurth, of Berlin.

The Leopoldinisch-Carolinische Deutsche Akademie der Naturforscher, of Halle, has awarded the Cothenius gold medal to Dr. F. Zirkel, professor of mineralogy in the University of Leipzig.

Professor A. H. Sayce, of Oxford University, has been appointed Gifford lecturer in Aberdeen University for 1900–1902.

Professor Burdon Saunderson gave the Croonian lecture before the Royal Society on

March 16th, on 'The Electric Concomitants of Motion in Animals and Plants.'

PROFESSOR JEBB, of Cambridge, will deliver the Romanes lecture at Oxford, June 7th, his subject being 'Humanism and Education.'

THE following Friday evening discourses are being given before the Royal Institution, London: March 10th, 'Measuring Extreme Temperatures,' by Professor H. L. Callendar, F.R.S.; March 17th, 'The Electric Fish of the Nile,' by Professor Francis Gotch, F.R.S.; and on March 24th, 'Transparency and Opacity,' by Lord Rayleigh, F.R.S.

PROFESSOR C. C. GEORGESON, of the Department of Agriculture, has left Washington for Sitka to superintend investigations in experimental agriculture. A building will be erected at Sitka this year which will contain offices for the experiment station and for meteorological observations.

THE Lord Mayor of Liverpool entertained, on March 4th, Professor Oliver J. Lodge, in recognition of his having received the Rumford medal, which is awarded biennially by the Royal Society for the most important discoveries in heat or light. Speeches were made by the Lord Mayor; Professor Fitzgerald, of Dublin; Sir John Brunner; Professor Myers, of Cambridge; Professor Rücker and Sir W. Crookes. It was announced at the dinner that Sir John Brunner had offered £5,000 towards a new building for the physical laboratory for University College, Liverpool, which is under Professor Lodge's direction.

A STATUE in bronze of the late Dr. William Pepper, of Philadelphia, will be erected in the plaza before the City Hall.

PROFESSOR JOHN COLLETT, for many years State Geologist of Indiana, died at Indianapolis, on March 15th, aged 71 years.

DR. W. HANKEL, professor of physics in the University of Leipzig, died on February 18th, at the age of 84 years.

DR. FRANCIS M. MACNAMARA died on March 5th, at the age of 57. He was formerly professor of chemistry at the Calcutta Medical College and chemical examiner to the Governor of India, where he made important investigations on the spread of cholera by water and on the distribution of disease.

CONGRESS, in its closing hours, passed a bill containing the stipulation, "That before January 1, 1903, the fence around the Botanical Garden shall be removed, provided that at the first session of the Fifty-sixth Congress the Joint Committee on Library is directed to report a bill embodying a plan for removing the Botanical Garden to another location." The Botanical Garden in Washington has done little for science, being administered by a Joint Committee on the Library of Congress. It is proposed to remove the Garden to a place where a larger area can be secured, and establish there a National Botanical Garden, which will probably be placed under the charge of the Department of Agriculture.

THE New York City Board of Estimate and Apportionment authorized, on March 17th, an issue of bonds to the amount of $500,000, the proceeds to be used in defraying the cost of removing the Forty-second street reservoir and in laying the foundations for the building for the New York Public Library, Astor, Lenox and Tilden foundations. Mayor Van Wyck is reported to have said: "The original request was for $150,000. We looked the matter over carefully and concluded that such a sum would suffice only for the demolition of the reservoir. It was suggested that the first requisition for bonds under the act authorizing the construction of the library be large enough to cover the cost of the foundations for the structure. The trustees of the library agreed to this, and the plans were accordingly amended. With $500,000 it will be possible within nine or ten months to raze the reservoir and lay the foundations. Then we shall be ready to order another issue of bonds and to prosecute the work to an early completion." The New York City Board of Estimate and Apportionment has also set aside $63,000 for work on the Zoological Garden in Bronx Park.

MAYOR VAN WYCK has given a public hearing on the bill passed by the Legislature authorizing the Board of Estimate and Apportionment to increase the annual appropriation for the American Museum of Natural History from

$90,000 to $130,000. Professor Albert S. Bickmore, representing the Museum, and Senator Plunkitt, the introducer of the bill, declared that, on account of recent additions to the building, more money was required for its maintenance, the present allowance being inadequate. The Mayor did not publicly declare his intentions towards the bill, but it is believed that he will sign it.

The Joint Committee of the Royal Society and the Royal Geographical Society, appointed to promote a National Antarctic Expedition, made application some time ago to the Council of the Royal Society and the Council of the British Association for grants of money in aid of the proposed expedition. The Treasurer of the Royal Society has applied, on behalf of the Council, to the Government Grant Committee for a grant of £1,000, and the Council of the British Association will recommend to the next meeting of the General Committee that a like sum be contributed by the Association. The scientific societies in Australia are moving in the matter with a view to influencing the Premiers of the different colonies.

The Navy Department expects to make a hydrographic survey of the Philippines. The *Vixen*, now on its way to Manila, will begin the work as soon as it can be spared, and it is expected that the *Yosemite*, after making surveys about Guam, will proceed to the Philippines for this purpose.

Dr. W. H. Furness and Dr. H. M. Miller have returned from an expedition to Florida, where they have been collecting fossils for the Wistar Institute of Anatomy, University of Pennsylvania. They have made collections from the limestone quarries and phosphate mines, where Dr. Leidy secured many valuable specimens.

The will of the late Herbert Stewart gives $2,000 to the American Society of Engineers for a library fund and $500 to the Engineers' Club of New York City towards its building fund. The residue of the estate, subject to life annuities, is left to the Sheffield Scientific School of Yale University for Scholarships. The amount is estimated at $40,000.

A Civil Service Commission examination will be held on April 11 and 12, 1899, for the position of Soil Chemist, Division of Soils, Department of Agriculture, at a salary of $1,400 per annum. The subjects and weights are as follows:

Physical chemistry	20
Inorganic chemistry	20
Organic chemistry	20
Analytical methods	20
Literature of soils	10
French and German	10
Total	100

On the same days an examination will be held for the position of Special Crop Culturist (Department of Agriculture). The subjects will be weighted as follows:

Basis examination (first grade)	10
English composition and general training and experience	10
Agriculture and horticulture (general principles and practice of agriculture and horticulture, including crop rotation, selection and breeding of variety, agricultural Chemistry, fertilizers, treatment of plant diseases and insect pests)	20
French (translation into English of a selection relating to the cultivation of field crops)	10
Field crops (treatment of miscellaneous and little known field crops, including import statistics)	30
Proof reading	10
Typewriting (tabulating, copying and spacing, and writing from dictation)	10
Total	100

We have already called attention to the Volta commemoration to be held at Como during May of the present year. Como has appropriated $100,000 for the preliminary expenses. An electrical exhibition will be opened on May 14th. A congress of electricians will also be held.

The eleventh annual meeting of the Botanical Society of the University of Pennsylvania was held this week, and the following officers were elected: President, *ex-officio*, Provost C. C. Harrison; acting President, Dr. Adolph Miller; First Vice-President, Mrs. L. R. Fox; Secretary, Professor J. MacFarland; Treasurer, R. C. Beane.

We learn from the *British Medical Journal* that the French Medical Press Association held

its forty-third meeting on February 3d, under the presidency of Dr. Gézilly. It was decided to organize an International Congress of the Medical Press, to be held in Paris in 1900, at the same time as the other congresses which are to take place there in that year.

THE beginning of an arboretum will be made made at the University of Michigan this year, under the direction of the pharmacy department. The plan is to have specimens of as many different kind of trees growing on the University campus as will thrive in the latitude. Special attention, however, will be given to the securing of trees of medicinal or economic importance. A few trees will be set out each year, being selected and planted by the members of the graduating classes of the pharmacy department.

THE report of the committee appointed by the Council of the Society of Arts to inquire into the requisite conditions of safety in acetylene gas generators, and to report on the various apparatus shown at the exhibition held at the Imperial Institute, says the London *Times*, has just been issued. The object of the exhibition, which was undertaken with the approval of Sir Vivian Majendie of the Home Office, and of the London County Council, was to familiarize the public with the means of generating acetylene gas, and with the simple precautions with which its use at low pressures is as safe as that of coal gas. The committee, feeling that in the interests of the public it was advisable carefully to test the various forms of generators exhibited, appointed Professor Vivian B. Lewes and Mr. Boverton Redwood as a sub-committee to make a series of tests. As a result of these tests the committee have advised the granting of certificates to those generators which have complied with the requirements of the various tests to which they have been submitted, and which have worked safely and satisfactorily during a month's every-day use. The committee classified the generators into three groups: (1) those in which the gas is generated by water being allowed to drip or flow on to the carbide; (2) those in which the water is allowed to rise in contact with the carbide, the rise being regulated by the increase of pressure in the generating chamber; (3) those in which the carbide drops into the water. These are again subdivided into automatic generators whose storage capacity is less than the total volume which the charge of carbide is capable of generating, and which, therefore, require automatic regulation; and non-automatic, whose holders can receive all the gas produced by the charge of carbide. The committee consider that the tests have clearly demonstrated that many types of acetylene gas apparatus can be so constructed as with ordinary precautions to be absolutely safe, and that lighting by acetylene need be no more fraught with danger than any other form of artificial lighting in general use. The committee, however, feel it their duty to state that, safe as they consider acetylene gas to be, when generated in a properly-constructed apparatus outside the building to be lighted, and in accordance with the rules and suggestions contained in the report, they consider the generation of gas within the house, and the use of hand lamps, cycle lamps, etc., to be not unattended by danger, except in skilled hands. As to the storage of the carbide, the Home Office regulations allow 5lb. to be kept without a license in 1lb. packages. The committee recommend that the quantity, however small, should always be kept in a dry place, and under lock and key. These precautions, they think, may not be necessary when its properties are fully understood, as it is no more dangerons than many other substances in daily use.

THE Reale Instituto Lombardo announces in its *Rendiconti* the award of its prizes which are quoted in *Nature* as follows: The Cagnola prize of 2,500 lire and a gold medal of 500 lire has been awarded to Signor Angelo Battelli and Signor Annibale Stefanini for their joint paper containing a critical exposition of electric dissociation considered principally in regard to the experimental proofs of its deductions. For the Kramer prize, on an essay relating to the use of condensers in the transmission of electric energy by alternating currents and their construction for industrial purposes, two competitors entered, and prizes of 2,500 lire and 1,500 lire respectively have been awarded to Professor Luigi Lombardi, of Turin, and Signor Giovanni Battista Folco,

director of the electric tramways of Leghorn. For the Fossati prize, on some physiological point connected with the human encephalus, two competitors entered, and awards of 400 lire have been made to both—namely, Dr. Domenico Mirto, of Palerma, and Dr. Carlo Martinotti, of Turin. For the Brambilla prize, given for the invention or introduction of some new machine or industrial process of real practical value, seven competitors entered. A gold medal and 500 lire has been awarded to Fratelli Boltri, of Milan, for their grain desiccators; a similar award to Premoli and Zanoncelli, of Lodi, for their preparation of Gaertnerised milk. Gold medals and 200 lire have also been given to Rossi, Enrico and Co., of Milan, for their manufacture of varnishes, etc.; to Piola Alfredo, of Milan, for artists' colors; and to Pizonni Pietro, of Milan, for the manufacture of baskets. The prizes offered for future competition include prizes of the Institution for 1899 for a list of unusual meteorological events that have been recorded from the earliest times, and for 1900 for an essay on collective property in Italy; two triennial medals for improvements in agricultural or industrial processes in Lombardy; a Cagnola prize and gold medal on the subjects chosen by the Institution, viz., in 1899, for an essay on Hertz's phenomenon, or the effect of active radiation or of products of combustion on the sparking distance in air, and in 1900 for a critical study of toxin and anti-toxin; a Cagnola prize and gold medal for 1899 on one of the following subjects chosen by the founder, viz: the cure of 'pellagra,' the nature of miasma and contagion, the direction of flying balloons, and the methods of preventing forgery of writings; a Brambilla prize for industrial improvements in Lombardy; Fossati prizes for 1899 on the macro- or micro-scopical anatomy of the nervous system, for 1900 on the regeneration of peripheric nervous fibres in vertebrates, and for 1901 on the anatomy of the encephalus of the higher animals; a Kramer prize for an essay on the transmission of heat between the steam and walls of the cylinders of steam engines; a Secco Comneno prize for 1902 for a description of Italian natural deposits of phosphates; a Pizzamiglio prize for an essay on the influence of socialistic doctrines on private rights; Ciani prizes for popular Italian books, a Tommasoni prize for a history of the life and works of Leonardi da Vinci; and a triennial Zanetti prize for some improvements or discovery in pharmaceutical chemistry.

UNIVERSITY AND EDUCATIONAL NEWS.

At a meeting of the Board of Overseers of Harvard University on March 15th it was voted to concur with the President and Fellows in the election of William Morris Davis, M.E., now holding the chair of physical geography, to be Sturgis Hooper professor of geology; Robert Tracy Jackson, S.D., was elected assistant professor of paleontology, and Jay Backus Woodworth, S.B., instructor in geology.

Dr. Simon Flexner, of the Johns Hopkins University, has accepted the chair of pathology in the University of Pennsylvania, to succeed Dr. John Guiteras. Dr. Guiteras will spend a year abroad and expects then to devote his services to the University of Havana.

Mr. H. E. Brown and Mr. W. A. Niveling, assistant instructors in chemistry in the University of Michigan, have resigned their positions to engage in technical work.

At Yale University Dr. Jervase Greene has been promoted to an instructorship in philosophy and Dr. I. K. Phelps to an instructorship in chemistry. Dr. Milton B. Porter has been appointed instructor in mathematics.

Colonel Heinrich Hartl has been appointed professor of geodesy in the University of Vienna, and Dr. G. Bodländer, of Göttingen, professor of physical chemistry in the Institute of Technology at Braunschweig. Dr. Gutzmer, of Halle, has been called to the new assistant professorship of mathematics in the University of Jena; Dr. Aladar Richter to be assistant professor of botany in the University at Klausenburg, and Dr. Bengst Jöhnsson to be professor of botany in the Academy at Lund. Dr. Tobler and Dr. Streckeisen have qualified as docents in mineralogy and geography in the University at Bâsle. Dr. Ad. Fick, professor of physiology at the University of Würzburg, will retire at the end of the present semester.